ENGINEERING

An Illustrated Weekly Journal

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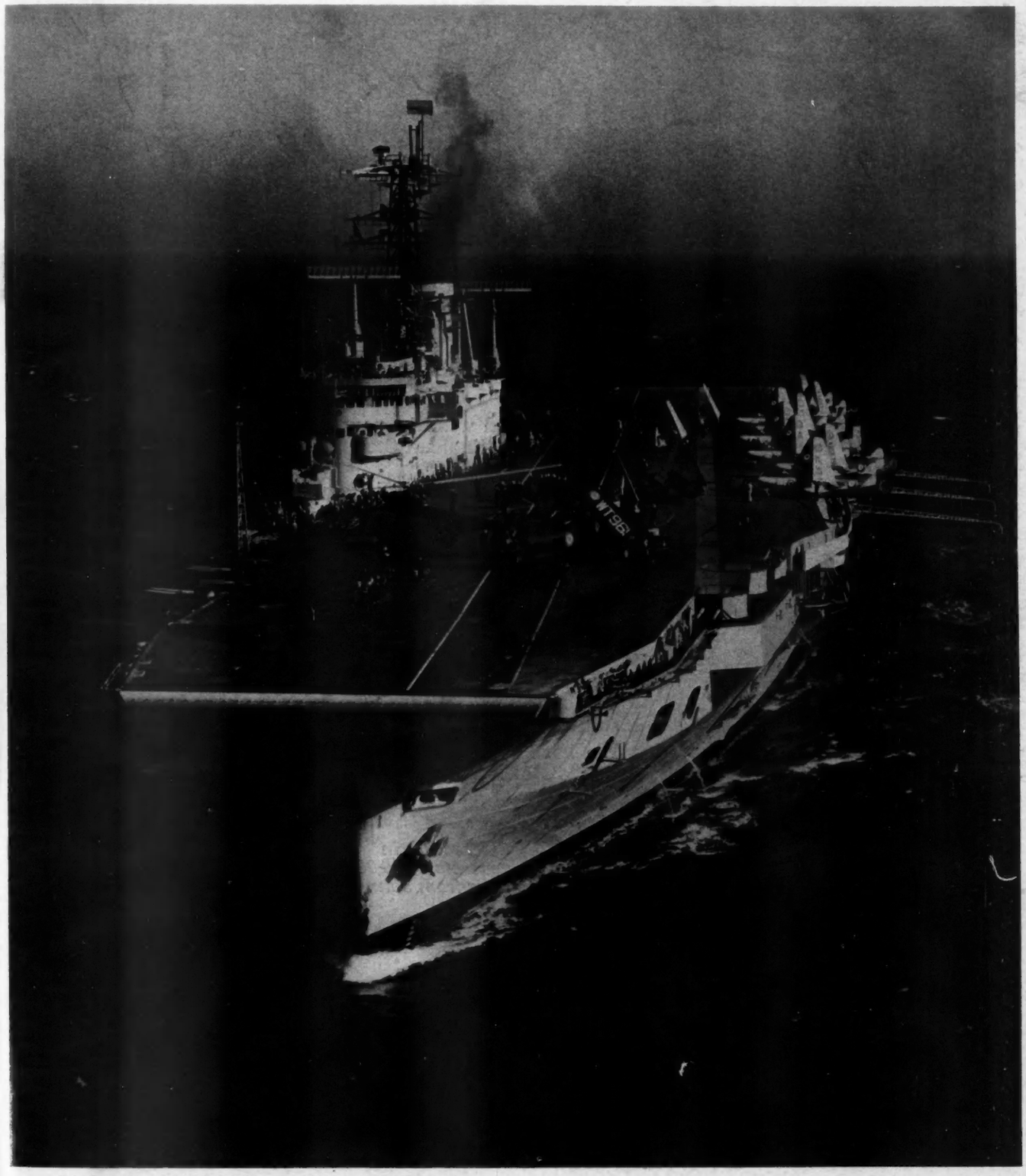

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THE FLYWHEEL

WHAT makes a business thrive? In spite of the political changes of the last 40 or 50 years Britain is still a country where new firms can and do spring up and prosper. A hundred years ago men were building railways; 90 years ago this journal was founded; 50 years ago motor-car firms were being founded. No one would want to build a railway in England to-day (unless it were a line from London to its Airport, but that is a job reserved for established monopolies); there is not much room for new technical journals, except of the mushroom type; and there are already sufficient motor-car manufacturers. It is a common gambit of conversation to say that because of high taxation and other restrictions to business no one could succeed as Henry Ford or Lord Nuffield succeeded. No one is likely to try in the motor-car field. But without doubt there is a handful of men in our midst in 1955 who are starting enterprises which will become equally famous in the fullness of time. These men are not making motor-cars: they are going for the opportunities which they, almost alone, can see ahead.

While they plough a lonely furrow there are many more who have their hands full guiding the affairs of established concerns. The question what makes a business thrive? is for them more subtle. The bigger the firm the easier it is to imagine that it travels almost by its own momentum. And so it does, in a sense. There are traditions in every facet of its activities—in employment, design, production, marketing, perhaps in management and research—which propel it as though by an unseen flywheel. Even if it is only moderately efficient, the goodwill that has been accumulated over the years preserves for it a hard core of old friends and customers. It is easy to remark, in abstract terms, that if too much reliance is placed on this it is the beginning of the end, but it is difficult to effect a transformation, a silent revolution that will preserve the best of the old while adding the new that is necessary.

The whole of Mr. Peter Drucker's recent book, *The Practice of Management*, can be regarded as a spot-light focussed on this problem. And a very powerful spot-light his book is. It is long-winded, as we remarked in a review last week, but its analysis of business provokes that fundamental thought which is essential in all industrial countries. He warns his countrymen that "there is real danger that in retrospect the United States of 1950 will come to look like the Great Britain of 1880—doomed to decline for lack of vision and lack of effort." While Americans are, perhaps, heeding his warning we in this country, with a mis-spent 75 years behind us, might do worse than examine what makes a successful firm.

To speak of the aims and purposes of a firm—especially a large firm—is to mistake the outward signs of healthy activity for the motive power which is behind it. The aims and purposes are stated because they must be understood by executives, and in a translated form they should be accepted by all employees. They are ideas which can be communicated throughout the staff. But the principals and senior members of the firm, who state the aims and purposes in words, must be charged with vision and energy that no words can convey. It is they who make the business thrive. This is a great source of industrial strength in Britain. If one thinks of any well-known large firm it is almost ludicrous to ascribe aims or purposes to it, except in a very broad sense. It is nearer the truth to comprehend the combined power and influence of the large number of managers, engineers, physicists, accountants and so forth, each of whom is applying his strength because he is a member of one or other of these professions. A deeper understanding is to be found by considering one such whom we know: an engineer, say, who is prominent in his business and profession. It is hard to resist the temptation to name someone who is well-known in engineering, but it is necessary to stop short at this point and say that he (of whom the reader is no doubt thinking) is typical of those who make firms flourish. His ambition, tinged with idealism; his power to lead, softened by his desire to serve; his pride, balanced by the humility of experience; his success, based partly on good fortune—all these parts of the man, and others besides, are fused together in one person whose strength is the sustaining torque of the flywheel.

What, then, are the conditions which foster the growth of this kind of man? The glib answer is less penal taxation for the higher incomes. There may be some truth in that, but it is hardly the complete answer. Opportunities for advancement and initiative are important, but they depend on too many intangibles for them to be suddenly enlarged, and in any case "opportunity" smacks too much of self-interest to be in tune with contemporary feeling in Britain. It is more likely that a sense of how much more there is to be done is growing among responsible people. As such an awareness grows, as more men acquire it, the old and the new businesses will thrive. The revolutions of the flywheel will be maintained; a fresh impetus will be added to the momentum which has fluctuated at a high level for three centuries. There is real hope that the Great Britain of 1955 will come to look like the United States of 1880—destined to rise on vision and effort.

Weekly Survey

Cover Picture. *This recent photograph shows H.M.S. Ark Royal in the English Channel on her way to the Mediterranean on a six-months working-up cruise. She is the Royal Navy's most recently commissioned carrier and the first to be fitted with all the post-war developments in flight-deck technique. She is equipped with a 5½ deg. angled deck, port and starboard mirror landing-aids, a deck edge lift (the first to be fitted), in addition to two central lifts, two steam catapults, and improved arrester gear. She has a displacement of* 36,800 *tons and a peacetime complement of* 110 *officers,* 1,522 *ratings, and more than* 50 *aircraft.*

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Dr. Bronowski's Intelligent Guide to Coal

When coal has been freed by atomic energy " from the clutch of famine for power which holds it now " its future will be bright. Raw crude coal will be turned into a " highly efficient, smokeless fuel " first for the home and then for industry; processed coke will be developed to take the place of high-quality coke (more and more scarce) for steelmaking; the coal gases thus obtained, and later the coal itself, will yield raw materials for the chemical industry. Atomic energy will thus be the liberator, not the killer, of the British coal industry. This is the message left with his audience by Dr. J. Bronowski, research director of the National Coal Board, on the occasion of the seventh W. M. Thornton Lecture read to the Association of Mining Electrical and Mechanical Engineers last week. His paper " Atomic Energy and the Future of the Mining Industry " is a fascinating prognostication, and most stimulating.

Dr. Bronowski speaks for himself, not for the N.C.B. He visualises the progress of atomic energy electricity generation in three main phases: first, the C.E.A. plan for the building of 12 atomic power stations with an aggregate capacity of 2,000 MW by 1965. The electricity they will generate will be as much as would take five or six million tons of coal to make. During the same period coal-fired power stations with a capacity of over 10,000 MW and requiring some 25 million tons of coal a year will also be built. Dr. Bronowski points out, however, that the rate of building atomic power stations will be steeply accelerated after 1960 and may in fact exceed the figures quoted in the White Paper by two or three more power stations. The proportion of plutonium as a by-product will allow the charge of atomic fuels in the reactors of later types to be enriched: " the whole conception of the programme is something progressive, quickening and growing." The second phase, from 1965 to 1975, should see a rise in the capacity of atomic energy power stations to 10,000 MW—the equivalent of about 40 million tons of coal a year. Towards the end of this phase, new atomic energy stations should be able to take all the increased demand for electricity, which may then amount to 3,000 MW a year. There will be no call for new coal-burning (or oil-burning) power stations and the demand for coal and oil will remain steady at 60 to 70 million tons a year until existing coal-fired stations become obsolete and drop out of the system. " As they drop out, the demand for coal to generate electricity will actually fall; I expect it to have taken quite a dip before 1985."

The future of coal then brightens considerably: uneconomic marginal production need not be persevered with, the development of smokeless fuels now going on should open a major outlet for coal after 1965, and the " greater integration of our chemical industry with coal should follow." It may well be, therefore, that the advent of atomic energy will benefit the coal industry—provided development work keeps abreast of events. It is quite clear that the development of atomic energy for electricity generation, and hence for other uses, has been greatly stimulated by the coal mining industry's failure to keep up with demand.

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Economy Without Emergency?

Voltaire said that Admiral Byng was shot on the quarterdeck of his flagship " to encourage the others." Mr. Butler seemed determined last week to carry out a similar exercise by shooting at the British economy. His Budget makes most sense only if it is viewed as a gesture on his part to persuade those abroad whose confidence in sterling has wilted from time to time that he is prepared not only to talk sternly at Istanbul but to act sternly at home. This autumn Budget should be judged as a series of defence measures on behalf of the pound and it follows from this that its virtues will be apparent only after the lapse of some time.

Its vices have been quickly enumerated—by the Opposition, by trade unionists, by some people in the City and by those who take it upon themselves to speak for the British housewife. The closer one looks at the individual provisions the more difficult it is to see in them a coherent policy. The purchase tax increases are clearly intended to restrain the public buying and so prevent the consumer goods industries from exacerbating the inflationary situation. So far it is these changes which have caused the uproar, but there is, in fact, a good deal to be said for them. If they raise the cost of living without stimulating the output of consumer goods, that is if prices go up while output remains stationary, they will have achieved the Chancellor's aim. This may well happen rather than a cut-back in production taking place.

On the capital goods side, the situation is much more complex. Housing subsidies are being cut but local authorities can still build houses if they are prepared to pay the higher rate of interest now current in order to do it. Farmers—that privileged race—are keeping their subsidies and therefore their capacity to buy new equipment (which is considerable). No further active measures than those announced at the end of July are being taken to prevent the nationalised industries from expanding their capital equipment and it is this group of industries to-day which provide the major dynamism behind the demand for plant and machinery. As a political gesture to the trade unions the Chancellor has raised the tax on distributed profits, which will make it increasingly attractive for companies to put their profits to reserve and so increase their capital resources—hardly an incentive to reduce capital investment unless the general climate of industry is not propitious. So far as the engineering industry as a whole is concerned, some industries, especially in consumer durable goods, may be adversely affected for some time but on the heavy side the impact may not be as serious as might at first appear for such cuts as are planned are in " paper plans " which have not yet been fully taken into account by engineering concerns.

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Dowty Group's Expansion

Since 1951 the profits of Dowty Group, Limited, have gone up by 250 per cent. from £417,423 to £1,465,128, and over the same period the fixed assets of the company have increased by 140 per cent. This has been a notable rate of expansion and has been accompanied by a marked widening in the company's interests. To-day, according to the chairman's statement for the year ended March 31, 1955, over 30 per cent., of the Group's turnover is in the export market. The Group's activity in the last five or six years is therefore something of a microcosm of the engineering industry as a whole. It is interesting to note that the expansion in working capital of the group from £422,200 in 1951 to £1,699,778 represents a rather larger expansion than the increase in profits (the working capital being struck after provision has been made for future taxation). There is nothing extraordinary in a company increasing its working capital rather more rapidly than its profits since it must inevitably carry larger stocks and probably more and larger debtors as turnover expands. The fact emphasises, however, the need in many sections of the engineering industries to-day for very large liquid financial resources in order to play a growing part in the national economy and in export markets.

It would appear that the company's expansion is likely to go on. To quote the chairman's remarks: " This is an interesting period in our company's history, and with many new technical developments there are considerable possibilities for expanding out varied interests." In 1949 the chairman referred to the development of the Dowty " walking chock " which it was hoped would solve the problem of continuous mining. The company now believes this goal to be in sight after six years of development work. A pilot scheme has been working and within the next 12 months it is hoped to see a full coal face in operation. In the oil industry the company is engaged in increasing the efficiency of pumping, and tests are to be carried out in the near future at oil wells. On rail, Dowty are working on developments to improve the efficiency and reduce the maintenance costs of rolling stock and in road transportation a new form of hydraulic drive is now being tested in Canada. Special consideration has been given to the use of disabled workers and the company has undertaken to equip one of the Remploy factories with plant for the manufacture of some of its products. The company hopes to show that such factories can be economically employed by industries instead of being subsidised by the State.

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Diesels in Demand

The favourable outlook that now prevails for the Diesel engine industry is beginning to be reflected in the output figures. Deliveries in the second quarter of the year were 25 per cent. higher than a year ago, and most firms in the industry have a considerable volume of work on hand. The fall in armament orders seems to have been more than offset by rising commercial demand. Exports have also recovered substantially and during the second quarter accounted for 36 per cent. of the total value of output, the same as during 1954. There may be some setbacks due to import restrictions recently imposed in some markets, but this is unlikely to affect the general level of activity in the industry. Locomotives, railcars, commercial vehicles, contractors' plant, Diesel generating sets and Diesel pumps, which are the principal outlets for engines, are also in good and rising demand and shipbuilding goes from strength to strength with Diesels gaining steadily on other forms of propulsion. So far, competition from gas-turbine drive for smaller ships, and for industrial applications, has been slight and there are no signs that gas turbines will make much impression on Diesel sales for a good many years.

Sir Kenneth I. Crossley, chairman of Crossley Brothers, Limited, said, however, in his speech to the annual general meeting of the company's shareholders, that rising costs constituted a major threat to the industry's ability to compete overseas. This is, of course, valid for the whole of British engineering and the situation has not been improved by Mr. Butler's autumn budget. On the whole, however, taxation is the ally of the Diesel engine industry and there seems little doubt that output will continue to expand.

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Oriental Betterment

A good deal of discussion is going on at present about the future organisation of the Colombo Plan. Since the first meeting of the Colombo Plan Consultative Committee at Sydney in Australia in May, 1950, the scheme has made excellent progress with a minimum of organisation. There is an influential body of opinion, among which the United States is prominent, which would like to see the various schemes and agencies for carrying out economic aid for South

East Asia brought into some coherent plan in an effort to avoid waste. On the other hand such countries as India have noted with approval the ability of the Colombo Plan to bear fruit without the assistance of a large number of administrators from the Western Powers. They would like this streamlined form of organisation to continue.

By present-day standards the numbers and the sums of money involved are not spectacular but if the Colombo Plan can develop the technique of helping to train rapidly managers and technicians for South East Asia it will have made an invaluable and unique contribution towards the raising of the standard of living in the Orient. One of the tests of a healthy scheme of this kind is the amount of money and manpower spent on productive schemes as opposed to welfare projects. By this test the Colombo Plan does well.

* * *

Accumulators on Show

It is fast becoming the hallmark of industrial significance, indeed almost of respectability, to be on the list of industries to be investigated by the Monopolies Commission. The accumulator manufacturers have now joined this select group. Whatever may be the results of the investigation when it takes place, this is an industry which always breathes an air of robust competition so far as technical advancement is concerned. In the last week or so both the Chloride Electrical Storage Company Limited, and Oldham and Son Limited, have been discussing enterprise and technical advancement. In the case of Chloride Electrical it was to mark this year's Motor Show and in the case of Oldham and Son it was at the company's 90th anniversary dinner.

The production of accumulators does not follow closely the trend of output of motor vehicles. The size and age of the existing car and commercial vehicle population plays an important part in the demand for batteries and there are signs that replacement is sensitive to price changes. The output of accumulators in 1954, was slightly higher in terms of value than in 1953. It was still below the levels achieved in 1952 and 1951. In the current year so far the indications are that demand is recovering, but for some time past it is probable that some sections of the industry at any rate were selling slightly fewer accumulators at slightly higher prices. In the export market, business is still below the levels achieved two or three years ago. In dry-cell batteries, however, 1954 was a better year than 1953 and it also exceeded the level of output reached in 1951 and 1952. Higher exports have played an important part in this performance. In Britain, where service facilities are very extensively developed, dry-cell batteries are not of great importance.

Chloride Electrical are now making extensive use of Porvic, and their plants are now turning out twice as much as was envisaged, without increasing production space or capital expenditure. Before production of a mechanical separator like Porvic was started, over £500,000 worth of materials was imported annually. Instead of this import bill the company is now able to export Porvic separators both to the United States and Canada—whereas formerly they were imported into this country. Here is one more example of an American company (it will be recalled that Chloride Electrical has an American associate) finding it cheaper to manufacture in this country and export back into the American domestic market owing to the favourable wage rates in Britain compared with those obtaining in the United States.

As Oldham and Son move towards their centenary, nearly 50 per cent. of their business is represented by direct exports and overseas manufacture, the whole of the overseas business having been developed since the war. Fibrak, which is claimed to be one of the first synthetic separators to be developed after the industry changed over from wood, is now made in three continents, and Power Seal is expected to make a bid for use in all forms of battery storage in the near future.

Party Line

The Post Office is reported to be working on a new charges scheme, and telephone rentals may go up in the New Year. These were last raised in 1952 when the quarterly rate for London was fixed at £2 2*s*., and at £1 10*s*. in most other districts. Higher rates have done little, however, to stem the tide of people who would like to be "on the 'phone". In the year ended March, 1953, 386,000 applications were received by the Post Office, and in the following year the number rose to 413,000. In spite of this, much has been done to reduce the waiting list. Six years ago this stood at over half a million, but now numbers only 381,000. Where the underground and exchange equipment is already in existence there is little delay, but where these have to be installed the delay is considerable. The expansion of the service has inevitably involved the Post Office in extensive capital expenditure. Last year £68 million was spent, while in the current year planned expenditure is little short of £80 million. Higher rentals will help to finance these developments.

The fact that ducts and underground cables account for over half the expenditure gives force to the argument that there should be official encouragment of shared telephone services. About 8 per cent. of the total rented at the business rate, and 30 per cent. at the residence rate are party-line connections. Sharing a line with a neighbour is not a popular idea in this country, and less so if the element of compulsion is present. In practice, it is much less inconvenient than one would imagine. It is clearly wasteful to have a pair of wires all the way from one's house to the exchange if it is to be used only infrequently, and the actual cost of establishing an exclusive connection of this sort must be quite substantial. The economies to be derived from an extension of shared service connections need little elaboration.

In the United States, where the distances involved are often very much greater, a shared service is quite common. Once it is no longer necessary to compel the sharing of lines the Post Office could well encourage the continuation of the system on a voluntary basis to economise resources. To do this they ought to allow the sharing subscribers a fair share of the economies achieved by granting substantial reductions in rental charges. It is unlikely that the present difference of 9*s*. 6*d*. per quarter will tempt many subscribers to opt for a party line.

* * *

Aswan High Dam

British consulting engineers have secured one of their finest prizes ever with the retention of Sir Alexander Gibb and Partners, of Westminster, as consultants for the new Aswan dam on the River Nile. The dam, three miles long and with a maximum height of 330 feet, will create a reservoir 400 miles long reaching 150 miles into the Sudan. From the impounded water it will be possible to generate annually, 4,250 million kWh, 10 times Egypt's present consumption—and provide irrigation for another two million acres, so increasing the country's arable land by 30 per cent. The site of the new dam is four miles upstream of the existing Aswan dam, built in 1902 and later raised, the value of which will end with the completion of the new work in ten years' time.

Much of the political temper of Egypt is dictated by the Nile, for the country is almost entirely dependent upon it for resources and wealth. There has, indeed, always been a fear in Egypt that the river might be "damned" before it reached the country and control of the river has been the major issue in Sudan-Egyptian relationships. It is known that Egypt has offered the Sudan an equal share in the extra water to be made available for irrigation, and the ratification of such a treaty between the two countries is likely to be an essential prerequisite to the World Bank authorising a loan to aid construction. It should be noted, however, that there are almost innumerable locations further upstream where hydro-electric schemes might be sited without in any way restricting the purpose of the new dam. For example, the new Owen Falls dam in Uganda is at the Lake Victoria source and more than half the fall in the river occurs before it has flowed far into the Sudan.

With the signing of the agreement with the consulting engineers, the scheme enters the detailed stage. The work will later go out to international tender and it is to be expected that American, European and British contractors will compete for the work. The total cost is put at £E209 million and Russia is already reported to have offered financial help. Hungary and East Germany have said that they are ready to provide machinery and engineers in return for Egyptian cotton. Apart from the request to the World Bank—who are known to be favourably disposed towards the scheme—there is also an understanding that a *consortium* of British, French and West German banks should raise £45 million towards the cost. With all these offers of help it is of considerable note that the Saad el Aali Authority, the body responsible for the execution of the project, should have selected British consulting engineers as their technical advisers for the design and the supervision of the construction of the dam.

* * *

Densified Wood

Production has been increased considerably just recently of the comparatively new product known as densified wood, one of the largest producers having expanded its factory space and also arranged to manufacture abroad. It is claimed that the product is harder than any solid wood and lighter than any solid metal, and, weight for weight, is stronger than steel and offers a union of the best qualities of both wood and plastics. It is a laminated wood material made by assembling multi-layers of resin-impregnated veneers and highly compressing these in large presses. The process forces the resin through the thin strips of veneers, welding these into an almost indestructible and homogeneous block or board. The compressing reduces the original thickness by about 50 per cent. to form a very strong and versatile material of excellent dimensional stability, toughness and strength. Densified wood has a high resistance to water, chemical attack, abrasion and extremes of temperature, and its properties include tensile and compressive strengths of 18,000 lb. per square inch, with a shear strength averaging about 4,000 lb. per square inch. It can be machined either with modified woodworking equipment or the usual metal-working machine tools. The manufacturing process originated in France, but densified wood is now made in this country by the following three firms: "Permali"—Permali, Limited; "Hydulignum"—Hordern-Richmond, Limited; and "Jabroc"—Moulded Components, Limited.

Experiments and practical use has shown that the material has great possibilities, and in some cases its unique qualities have ensured it being used in substitution for metal and other materials, particularly under arduous conditions. Typical uses to which densified wood is already being put are for repetition engineering moulds, dies and patterns, parting boards for foundries, textile picker sticks, rollers, bobbins and shuttles, fire-resistant table tops, sports goods and fishing rods, aircraft propellers, etc. Considerable quantities are also being used for pulley wheels and blocks and as intermediary gear wheels to lessen noise and wear occuring between metal-to-metal trains of gears.

As the material is a non-conductor of electrical energy and impulses it has been used successfully in the construction of certain parts of naval vessels, especially submarines, to avoid interference with radar and other equipment sensitive to electrical impulses. Other electrical purposes for which it is being used is for electrical accessories such as switch gear, and for crossover junctions of overhead cables feeding trolley-buses and electric locomotives.

Facilities for training disabled men in light engineering at the Portland Training College include a fully-equipped workshop, where individual tuition is given in both bench and machine work.

ENGINEERING WORK FOR THE DISABLED

TRAINING FOR SKILLED OCCUPATIONS

It is well known that facilities exist in various parts of the country for training disabled persons in skilled work. Not so widely appreciated is the fact that numbers of men are trained for skilled engineering work, and that only in a minority of cases are sheltered workshops and special working conditions necessary. Most of the trainees take their place in industry alongside their able-bodied fellow-workers, and, working under exactly the same conditions, keep their jobs on merit. An example of what is being done in this respect is provided by the Portland Training College for the Disabled, Harlow Wood, Mansfield, Nottinghamshire, where, among other trades, engineering is taught to men suffering from a variety of disabilities, many of them apparently insuperable.

Portland Training College was opened in July, 1950, and is a voluntary organisation taking its name from the late Winifred, Duchess of Portland, who was largely responsible for its foundation. It is a residential establishment, with accommodation for 100 trainees, and teaches, at present, seven occupations: clerical, bench carpentry, surgical boot-making, boot and shoe repairing, gardening, watch and clock repairing, and light engineering.

RECRUITMENT

Admission to the College is on a voluntary basis, and is arranged in co-operation with the Ministry of Labour and National Service. About half the trainees up to the present have come from the Midland Counties, but men have been accepted from all parts of the country. Applications are considered from any male person from the age of 16 upwards who, because of illness or accident, is unable to follow his former occupation or who, for the same reason, may never have been in employment before. There is no specified upper age limit, and in certain cases youths under the age of 16 are accepted for training if sponsored by their local education authority. Men accepted for training are allowed a choice of occupation within limits imposed by their particular disability, and it is in this respect that the remarkable work of the College and the determination of the men first become apparent. Prospective trainees are guided in their choice by their medical advisers; obviously a man must not attempt anything which might injure him or aggravate his disability, and there are a few rules which must be observed. A serious epileptic case, for example, could not be employed on moving machinery, but apart from such obvious considerations no physical disability is allowed to deter either the men or their instructors.

On acceptance as a trainee a man becomes resident at the College, which provides pleasant living accommodation in rural surroundings, with excellent recreational facilities. Those trainees sponsored by the Ministry of Labour and National Service, who constitute the majority, are maintained during their period of training by the Ministry, and this is the only State assistance received by the College. Trainees work for 5½ days a week, 8 hours a day, thus becoming accustomed to the kind of working conditions they will experience when they take up full-time employment in industry or commerce. The remainder of the time is their own, but it is found that such is the keenness of the men, that a large proportion of the spare time of many of them is occupied with study.

TEACHING METHODS

The engineering course, which is run in conjunction with that on watch and clock repairing, but treated as an entirely separate subject, extends over six months. The maximum number of trainees accepted for the course is 12, which allows individual attention to be given to each man by the instructor. Training is both practical and theoretical, and the facilities available include a lecture room and a large, well-lighted workshop, with individual benches for each trainee. A range of machine tools is provided, which includes Myford 4½ in. sliding, surfacing and screw-cutting lathes, bench and pillar drilling machines and a Centec universal milling machine. Ancillary equipment includes grinding and polishing spindles, a bandfacer, and gas blow-pipes for brazing and soldering. A flypress is provided for proving press tools.

The training is based on a Ministry of Labour and National Service syllabus which covers all the essentials of precision engineering. The instruction given is aimed at developing any natural talents a man possesses, and there is provision for changing from one course to another should it be found that a man's bent lies in a different direction from that chosen. It should be added that the need for such a change rarely arises.

In their first week of training the men are put to work on simple tasks such as elementary filing, drilling, marking-out and caliper-setting. Lectures are given on general safety in the engineering workshop, and on the care and use of tools. From this simple work the men progress to similar but more skilled exercises, and at the same time the theoretical instruction becomes of a more advanced nature. The trainees are soon being taught how to read drawings, and shown the first steps in workshop arithmetic. By the third week they have been introduced to screw threads, and have been given talks on English and Metric standard threads. Screwing and tapping by hand are practised in the workshop. In the fourth week simple centre-lathe work begins, supplemented by lectures on the theory of machining, and so the trainees are taken progressively through the principles and practice of milling, sheet metal work, fabricating, soldering and brazing to more highly-skilled work such as the fitting of dowels and taper pins.

By the 16th week the trainees are dealing with cam-development, template and jig-making. The last few weeks of the course are devoted to such work as the fitting and assembly of mechanical movements, levers, cams, bell-cranks, and to the making of jigs and fixtures. Simultaneously with this more advanced practical work, instruction is given in the appropriate theory, electricity and workshop mathematics up to simple trigonometry being included in the later stages.

An important feature of the whole course is the stressing of the practical value of the theories taught and the bench work done. A man is given instruction on screw-threads, for example, and is then set to work making some useful workshop tool such as a bench micrometer, in which the importance of an accurately-cut thread is paramount. Such a tool will also demonstrate the practical application of numerous other techniques which have been taught, as the trainee will do his own dividing and engraving of the micrometer graduations, harden the spindle and lap the end, and assemble and finish the complete tool. No opportunity is lost to show the trainees that the skill they are acquiring has an immediate practical value, and that even the more abstruse subjects such as trigonometry are essential in many branches of engineering.

Similarly, the trainees are encouraged to think for themselves, and to apply the knowledge they have obtained to some useful purpose. An example of the methods used in this respect is provided by a task given to a trainee who was, at the time, in his fourth month at the course and who, prior to a tubercular illness, was employed in the retail carpet trade. He was given a revolution counter which was damaged before it came into the possession of the College, and asked, as a first step, to put it into working order. When this had been done, the trainee was told that the instrument would be useful to the College maintenance engineer, but that it would be necessary for it to be adapted to work on shafts rotating in either clockwise or anti-clockwise directions. It was left to the trainee to decide how this modification should be carried out, to do the necessary gear calculations, cut the gears from the solid, and to fit them and test the completed mechanism. The services of the instructor were available, but they were not given unless asked for, and the trainee carried out the modification successfully without assistance.

DEVELOPING CONFIDENCE

Such an exercise has the dual effect of showing the trainee the practical value of the various techniques he learns, and of giving him confidence in himself. It is his possible low rate of working that most worries a trainee who has had any experience of engineering before he arrives at the College, and this fact, coupled with

his disability, may make him a little doubtful of his competence to work with others on a competitive basis. The engineering course, like the others conducted at Portland Training College, is designed to dispel any fears of this kind which a man may have, and the results of the two years during which the course has been operating have shown how successful the methods have been. The trainees have proved themselves to be both confident and competent, and it has been the prospective employer who occasionally found it difficult to believe that a man so handicapped as some of the trainees have been really could do the job for which he was under consideration. Experience has shown that these doubts were unfounded, and most of the trained men have taken their place in industry and held it on merit. Occasionally it has been necessary to make some small modification to the working conditions, as in the case of a trainee who could only work in the standing position, and was given a bench higher than normal; mostly, however, the men go straight to an ordinary bench or machine.

In connection with some of the College course it is possible for trainees to take nationally-recognised examinations, but in the case of engineering the length of the course is insufficient to enable the men to sit for the City and Guilds of London examinations. However, the fact that a trainee has passed successfully through a College course is recognised by the Amalgamated Engineering Union, which co-operates in the placing of men in industrial employment. On completion of the course a report on each man is given by the College to the Ministry of Labour and National Service, recommending the type of work for which he is considered most suitable, and the Ministry then finds a situation for the man concerned.

Contact is maintained with each trainee and with his employer, to ensure that the men are given any advice or assistance they may need, and to enable the employers to comment on the work of the trainees placed with them. The success of the work done by the College is shown by the fact that just over 90 per cent. of the men trained during a typical working year were placed satisfactorily in industry or commerce. Of those who did not complete their training, 7 per cent. were compelled to give up the work through illness. In all, some 600 men have entered the College since it was opened in 1950, and nearly 90 per cent. of them have not only been successfully placed in work under normal conditions, but have given entire satisfaction.

Letters to the Editor

A SMOOTHER RUN

Analysing Railway Carriage Design

SIR, As an electrical engineer with an amateur interest in motor-car design I was surprised to read in your leading article of October 7 that railway carriage builders are at a loss to understand the reason for rough riding of multiple stock and the track wear caused by electric locomotives. Surely, the answer "unsprung weight" covers both cases and the difficulty is to reduce it, in the absence of a rubber tyre, for small-amplitude high-frequency oscillations.

I would suggest that rather than bother with running tests on four-wheel wagons, all that is necessary as a start is to measure, statically, tortional inertias and elasticities and set up the electrical analogue on a standard machine; then the way to big improvements will be clear to any knowledgable railway designer.

Yours faithfully,
T. ROBERTSON.

138 Bishopton-road,
Stockton-on-Tees.
October 20, 1955.

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SCIENTIFIC STUDY OF MAN'S WORKING ENVIRONMENT

A Neglected but Fruitful Field

SIR, In your issue of September 23, you reported on page 403 a paper on man-machine relationships which was given by Mr. Donald Wallis to the British Association, mentioning at the same time that the study of this relationship is the concern of members of the Ergonomics Research Society. These members are, in the main, research workers in the fields of experimental psychology and physiology, in anatomy, in industrial medicine and in any discipline touching man in relation to his work and working environment. Firms and associations are affiliated.

At the present time the results of research in this field are not as widely applied at the shop-floor level as they might be, for, I think, three main reasons. First, there is inadequate communication—research workers and industrialists hardly speaking the same language; there are no recognised channels for publication which are read by both, and designers and others hardly know where to go for information.

Secondly, as with most sciences, research results cannot be transferred direct from the laboratory without experiments, which must be carried out in industry by men who not only know industry's problems but also know the scope and limitations of the laboratory.

Thirdly, most industrialists do not believe there is much of value in the science. The potentialities of ergonomics have not yet been sufficiently appreciated for individual firms to set up teams to apply it. Yet the potentialities are immense. For instance, no one who has critically watched a man working on a centre lathe can fail to notice that however efficient the machine may be as a machine, the man-machine unit is inefficient. Controls often require long or awkward movements. The operator must often bend over in a tiring and unstable posture to see his work, and information about the position of the tool is given in an ambiguous manner by means of primitive scales. Even so simple a change as turning a lathe through 90 deg. and bolting it on to the wall (as it were) would make a vast improvement, but better still would be to design from the outset with the operator as well as the machine in mind—the improvement in productivity might be startling.

The picture is not entirely without hope. The British Iron and Steel Research Association have an ergonomics section currently engaged on the design of crane cabs; work on radiant-heat protection has also been sponsored based on the work of Professor Crowden of the London School of Hygiene. The British Boot and Shoe Trade Research Association have also a section in which a psychologist is working on the design of shoe-stiching machines, during the course of which methods of recording cycle times in repetitive work have been investigated with a view to understanding more about cycle-to-cycle variations in performance. Similar recording is being experimented with by the National Institute of Industrial Psychology, together with work on the effect of task and batch size on productivity.

The National Coal Board are sponsoring, at Oxford, investigations into environmental conditions in mines and into the physiological cost of mining; also at London University on some of the psychological problems in the industry. The motor trade is beginning to consult physiologists on anthiopometric data and control design, particularly on heavy vehicles where human efficiency does not have to take second place to styling.

At the Medical Research Council's Applied Psychology Unit at Cambridge research has been carried out on air-traffic control; on the effect of such variables as load and speed in the cotton industry and on the behaviour of vehicle drivers. The British Standards Institution are using data from psychological research in preparing a code of practice for the markings on instrument dials. Actually some gauge manufacturers have already changed their designs as the result of learning about this research and the findings are also beginning to be applied by Metropolitan-Vickers through their Appearance Design Office, which is also dealing with control design.

Nevertheless, what is being done is pitifully small. Many firms think that, given adequate bonus schemes, the men can be left to look after themselves. But in spite of this it has been shown, where it has been tried, that scientific study of man's working environment can pay very handsome dividends.

Yours faithfully,
K. F. H. MURRELL,
Honorary Secretary,
Ergonomics Research Society.

The Miners' Arms,
Priddy,
Wells, Somerset.
October 24, 1955.

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CITY AND GUILDS COURSES

The Institute's Function

SIR, May we draw attention to a statement in "Technological Courses: Engineering Firms Encourage Tuition in Special Subjects," on page 528, of your issue of October 14, referring to the above subject, which says "Another course . . . dealing with concrete practice to be held at the City and Guilds of London Institute," as we are afraid that this statement may cause misunderstanding in the minds of intending students.

The Institute's Department of Technology is purely an examining body and does not provide courses of instruction of any kind. Such courses, based on the Institute's schemes and leading to its examinations, are offered by the technical colleges and schools. Intending students in any of the subjects of examination offered by the Institute should therefore make enquiries from their local technical college and not from the Institute.

Yours faithfully,
E. G. R. WINGHAM,
for Director.

City and Guilds of London Institute,
Gresham College,
E.C.2.
October 24, 1955.

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ENGINEERING PROJECTS IN UNDEVELOPED COUNTRIES

Capacity of Tennessee Valley Authority

SIR, May I point out that the figure of "about 22,000 MW" for the installed capacity of the Tennessee Valley Authority, which was published in the article with the above title on page 485 of ENGINEERING for October 7, does not appear to be correct.

According to the 1954 Annual Report of the Authority, the "nameplate" capacity of plants in operation on June 30, 1954, on the combined Tennessee Valley Authority system (including plants of the U.S. Army Engineers and the Aluminium Company of America) was 6,075,685 kW. According to the same source the capacity under construction on the same date (which was scheduled for installation by June, 1957) was 3,924,800 kW.

Yours faithfully,
A. RUNACRES.

18 Lucknow-street,
Plumstead,
London, S.E.18.
October 27, 1955.

BRITAIN'S FIRST TRUNK LINE

RAILWAY CIVIL ENGINEERING IN THE 1830's

At the meeting held at the Institution of Civil Engineers on Tuesday, November 1, the new President, Mr. W. K. Wallace, C.B.E., was ormally introduced by the retiring President, Mr. D. M. Watson. The new President has had a long and distinguished career as a railway civil engineer, having been until 1948 *Chief Civil Engineer of the London Midland Region, British Railways. In his address, Mr. Wallace described the construction of the London-Birmingham railway, the first trunk line in the* 1830's. *This line was the work of Robert Stephenson, who was also responsible for many great bridges, in particular the Britannia bridge, the construction of which Mr. Wallace also described. A résumé of Mr. Wallace's remarks follows.*

ROBERT STEPHENSON'S PART

The first railway to be designed and built in Great Britain as a trunk line was that linking London with Birmingham (now forming part of the London Midland Region of British Railways). The first Bill, promoted in 1832, had intended the London terminus to be at or near Kings Cross, but a second Bill, passed in the following year, located the terminus at Camden Town. The prospectus issued in 1830 had shown the engineers to be Messrs. Stephenson and Son, but George Stephenson left the design and laying out of the railway mainly to his son Robert, though he was consulted frequently. Robert was in fact appointed Engineer-in-Chief on September 21, 1833, and by the agreement undertook to devote the whole of his time to the railway.

The authorised length of the line was 111¼ miles, the maximum gradient 1 in 330 and the line was double throughout with passing loops at intervals. By February 1836, the whole of the works, including the Euston extension, was let to contract, but quicksand had been found in the tunnel at Kilsby and this was to be a source of great trouble, expense and delay. The line was opened in sections, due to delays in completing some parts of the works, at various dates between July, 1837, and September 17, 1838, when the whole line was finally opened.

In 1834 Stephenson recommended that the permanent way should consist of fish-bellied rails of 50 lb. per yard on chairs of 20 to 22 lb. each " with a fastening that allows some deflection " supported on stone blocks not less than 2 ft. square by 1 ft. thick in the cuttings and by sleepers of larch or oak not less than 10 in. by 6 in. by 8 ft. 6 in. long on embankments. For fastenings, oak trenails and spikes were used for fixing the chairs to the blocks, and spikes only on to sleepers. Following some experiments by Professor Barlow at Woolwich, the weight of the track was increased and rails of 75 lb. per yard were used on bearings at 5 ft. spacing except for the 20 miles at the London end where rails of 65 lb. per yard on bearings 4 ft. apart were laid.

The decision to construct the railway with easy gradients and curves resulted in heavy earthworks. At that time excavation was a manual job, except where explosives were employed. Embankments were formed by end tipping from formation level or from borrow pits alongside. Cuttings were run to fill wherever possible and economical, and end-tip wagons holding about 1 ton, either horse drawn or hauled by locomotives, were the principal equipment.

There was considerable trouble from settlements and slips, the two contributing most to the delayed opening of the line being at Kilsby tunnel and Blisworth (now Roade) cutting. In the latter case slender face walls 20 ft. high and tapering from 4 ft. to 2 ft. thick, strengthened by buttresses at 20 ft. centres, were built to prevent dangerous falls of boulders due to weathering of the exposed strata.

Bridges, though numerous, were not of outstanding span or height; neither were the 13 viaducts built along the line. Construction was usually of red brick, though some stone structures were erected—probably to meet the requirements of local landowners. Stone copings were usual and stone voussoirs were sometimes employed. Four underbridges carrying the line over the Grand Junction Canal were built with cast-iron arches on the skew and varying in span from 45 to 68 ft. (The original superstructures are still in use, additional spans to carry the widened line having been added later.)

THE FIRST RAILWAY TUNNELS

Although tunnels had been constructed for canals, engineers generally as well as the public considered them undesirable for railways. The fears were not due to suspicions of the structural safety of the tunnels but to the belief that they would become so foul as to endanger the health of the passengers. Stephenson obviously held a different opinion and his plan called for eight tunnels varying in length from 288 yards to 2,394 yards. All were built for the double line and the width varied from 22 ft. to 23 ft. 6 in. Construction was generally of brickwork, but with stone portals in some cases. Five of the tunnels—Kensal Green, Watford, Northchurch, Linslade and Beechwood—seem to have been built without undue difficulty as no special reports on them can be traced. The remaining three—Primrose Hill, Stowe, and Kilsby—proved more difficult, particularly the classic case of Kilsby. This last-mentioned tunnel, the longest on the line (1 mile 666 yd.), was expensive and difficult; for more than 500 yards construction was through a bed of quicksand, and the remainder was through very wet ground.

That these conditions were foreseen is shown by Stephenson's own writings. He noted that he was induced to adopt two large shafts (60 ft. diameter ventilating shafts) not merely on account of the great length of the tunnel, but also from " a conviction that it would be found wet which would render every possible expedient for assisting through ventilation highly desirable." Considerable thought was then given to the adoption of a deviation line but as nothing better was found the accepted alignment was adhered to. By February 1836, five shafts had been sunk; three were standing owing to water (one in the quicksand area) and two were sunk to tunnel level. Drifts were also in hand at both ends to drain away water and the large ventilating shafts had been commenced.

Following difficulties with the contractors, the contract was relinquished in March, 1936, and the work carried on by the administration. Stephenson set out the methods he proposed to adopt as follows.—

" Lay a temporary line of railway along the surface.

" Sink seven more shafts in the sound ground, one south of, and six north of the quicksand. These, with the three existing working shafts will divide that part of the tunnel which is free from quicksand into lengths 200 to 220 yards long, to be worked from each shaft. Three shafts to be worked by horse gins, the others by steam engine. (Finally, no less than 25 shafts were sunk).

" Continue with the draining of the quicksand and determine the number of shafts to be sunk when the draining is nearly completed.

" Erect a steam clay mill with kilns sufficient to supply 30,000 bricks per day, say, a total quantity of 20 million bricks."

No report now remains of when the tunnel was completed but, as already noted, the line was opened on September 17, 1838.

OVERCOMING GRADIENTS

The extension to Euston included, of necessity, a steep gradient of 1 in 70 and practically the whole length was in cutting due to the rapid rise in the ground so that retaining walls were required for the greater part of the distance, and a number of bridges were necessary to carry roads over the line. Since the gradient was considered too steep for operating locomotives, two 60 h.p. winding engines were erected close to the top of the incline and the trains were hauled up by an endless rope. The winding engines were not ready for the opening of the line and a " powerful engine " was hired for three months from Robert Stephenson and Company, Newcastle, to bank the trains up the incline. Rope haulage was retained until 1844.

Apart from the " grand but simple portico," the terminal buildings were not remarkable. Two platforms were provided, each about 420 ft. long, roofed over for part of their length, and two intermediate sidings were laid between the main lines. All the lines were connected by turntables at the buffer stops, at the end of the platform roofing, and at the platform ends, where a short siding at right angles to the running lines connected with another road leading to the carriage shed. As all the rolling stock, including the locomotives, were at first four-wheeled the turntables were small, but shunting must have been a lengthy process since, owing to the absence of points and crossing work, no direct movement between roads was possible.

Considerable difficulty was experienced with the retaining walls in the area, and their design was criticised in a paper read by Professor Hoskin to the Institution in 1844, who observed that " these walls . . . have failed to a considerable extent." A system of strutting with cast-iron beams placed between the walls was applied to meet the exigency. A year later in the discussion on another paper Stephenson observed that the walls of the Euston incline " were instructive examples of the discrepancy between theory and practice." The walls were designed, he said, before he had obtained his experience of the effects of London clay.

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IMPERIAL COLLEGE

Expansion Problems

Representatives of nearly 600 students of the Imperial College of Science and Technology elected to Associateships of the three constituent colleges were presented to the chairman of the Governors and of the City and Guilds College Delegacy at the Commemoration Day ceremony on Tuesday, October 25. The large numbers who, with their guests, nearly filled the lower part of the Albert Hall, were due to the fact that no ceremony was held last year owing to the death of the Rector, Sir Roderic Hill. The very small number of women, even among the members of the Royal College of Science, was rather surprising, as also was the small number of overseas' students among those graduating for the first time. On the other hand among those receiving the post-graduate award of Diploma of the Imperial College the number of foreign students, particularly from the Far East, was noticeable. This emphasises one of the problems that the college is facing in its expansion plan. A large part of the additional facilities will be for post-graduate work, but at the present time, owing to the shortage of grants for such work, a majority of post-graduate students come from abroad. This is a problem to which industry and the Government will have to give increasing attention in the next few years.

A good deal was heard in the speeches of the Governor, the new Rector and the special visitor, Lord Adrian, about the expansion plan, but no indication was given as to the present position of the negotiations with the Government about the clearing of the site in South Kensington on which it is supposed to be carried out. When the matter was discussed in the House of Commons in July, the Financial Secretary to the Treasury said that it might be necessary to introduce special legislation to give effect to the promises made by the Government. Further delay must inevitably affect the smooth progress of the college's development.

REDUCING SIZE OF ELECTRICAL EQUIPMENT

GENERATORS, CONTACT RECTIFIERS, CIRCUIT BREAKERS

In the address which, as Chairman, he delivered before the Supply Section of the Institution of Electrical Engineers on Wednesday, October 26, Mr. L. Drucquer described at some length the ways in which the equipment used for generating, transforming and controlling electricity had been improved in recent years.

While the electrical loading of generating plant had increased, physical size had not grown at the same rate. In fact by the better and more skilful use of old and new materials and the adoption of new techniques the overall volume per kilowatt had been materially reduced. Progress in this direction had been assisted by the use of direct hydrogen cooling. On the other hand, the increase in steam pressures and temperatures had created problems of which blade and cylinder casing design and shaft distortion and expansion were representative. These problems had only been solved as a result of intensive metallurgical research and by such arrangements as double-walled cylinders.

Progress in the design of large power transformers had developed along fairly definite lines apart from the means of dissipating the heat generated. As a result of employing cold-reduced oriented silicon-steel strip the core section for a given loss had been reduced, thus permitting shorter copper length, smaller copper loss, reduced dimensions and lower oil volume.

During the last five years, the mechanical contact rectifier had been developed in this country and a 260 volt unit with a rating of 3,900 kW had operated satisfactorily over considerable periods in commercial service. Light power rectifiers of the semi-conductor type with ratings of 300 kW had been running in industrial service since 1953 and units of up to 2,300 kW were under construction. These two types of rectifier enabled a significant gain in efficiency to be obtained especially at low voltages, where values of 98·8 per cent. had been reached. This increase had been accompanied by a marked reduction in volume, the output per cubic foot having been trebled during the last five years.

The growth in the size and numbers of generators and the interconnection of stations had resulted in an ever increasing level of fault MVA. This had demanded switchgear of greater breaking capacity and values of 7,500 MVA had been reached during the last seven years. It was, however, no longer necessary to subdivide the network or introduce artificial reactance to reduce short-circuit levels. The raising of the breaking capacity level had been accompanied by a reduction of about 60 per cent. in the total break time. The goal of a three-cycle total break time, which included at least one half cycle of arcing time, was being approached. This progress had been reinforced by developments in high speed protective equipment with the result that the stability of interconnected systems had been improved, in spite of their increased capacity. It had further been accompanied by a marked drop in the volume per kilovolt-ampere of breaking capacity, which had been more than halved during the last 25 years.

Nearly 200 years ago the world learnt to use the new sources of power opened up by the inventions of James Watt and now once more we stand on the threshold of new discoveries which indicated that the future source of power lay in the conversion of water into energy. The nuclear reactor was the first practical attempt and in the more distant future it might be augmented by the greater use of power derived from natural sources.

AUTOMATIC CONTROL

Designers Needed for Full Exploitation

On October 11, Mr. W. Bamford gave his address as Chairman to the Measurement and Control section of the Institution of Electrical Engineers, in London.

He said that as a result of the progress made towards fully automatic production an additional class of equipment had been designed, which was concerned with the application of measurement to control, including computation. Automatic control could not always effect a saving in manual labour, but it did enable instructions to be transmitted at the rate a machine could accept them. As a serious labour shortage seemed to be imminent the need for engineers who could apply the new techniques must be emphasised and wherever machines could be designed to work without attention they must be made to do so. In fact neither the automatic factory nor its implications could be neglected.

As the use of automatic control increased so would its opportunities. There was no intrinsic or social value in making a measurement, the important thing was the use to which it was put. The best person to apply the measurement or the desired control was therefore the engineer whose knowledge had given him confidence in his technique and who had also absorbed some of the needs of the industrialist. If automatic measurement and control were successfully applied it followed that the quality of the product was under stricter control than with manual operation; and that the limit of quality was dependent upon the integrated errors of the various sections of the process. Better quality could, however, only be expected in so far as the plant was designed for the method. This led to the suggestion that the primary measuring device should come under the closest scrutiny in order that it might be of the highest possible accuracy.

The improved quality of the product would, in turn, lead to the improvement of the primary measuring instruments. In particular, the speed of response of the measuring device would have to be related to the equipment under control; components must be of a highly reliable type; and a greater degree of standardisation would no doubt be necessary. Above all the co-ordination of design throughout the production unit was vital.

All the present evidence emphasised the amount of hard work that was necessary before automatic control and production became common. More disturbing was the evidence that the number of trained engineers to design, install and maintain the equipment was likely to be insufficient for many years to come. Invention and discovery must, therefore, be speedily developed and applied to production, and the results of research must be adapted to suit the new conditions. The degree of co-operation between maker and user must be raised. This was a continuous process and, if it should break down, it could bring a stop to progress. Technologists should not ignore the social consequences of scientific discoveries and should give more time to the application of theories and principles to current problems, in order to ensure that no opportunity was lost to improve our methods in the industrial field.

The flow of technical information continued to increase. It must, however, be presented in a form which could produce results to engineers, technicians and, above all, to managers.

Obituary

MR. P. G. CORIN

Plant for Chemical Industry

We regret to record the death of Mr. P. G. Corin, M.I.C.E., which occurred in Leeds on October 14, at the age of 58. He was joint managing director of Henry Berry and Company, Limited, Leeds.

Philip Grosvenor Corin was born on August 14, 1897, and was educated at Shebbear College, North Devon, and at Cambridge University, where he graduated with Honours in the Mechanical Sciences Tripos. During the 1914-18 war he served in the Royal Artillery and, on leaving Cambridge in 1922, joined Imperial Chemical Industries Limited, with whom he was engaged on the design and erection of boilers, gas purification, ammonia synthesis and other chemical plant at Billingham. Four years later he joined the Process Department as shift manager in control of nitrogen fixation processes.

In 1928 he was promoted to group engineer in which position he was responsible for plant for the synthesis of methanol and, after a short period as transport group engineer, became research group manager in the branch connected with coal hydrogenation.

In 1932 he became deputy works manager in control of the machine and other shops and was responsible for designing a foundry for casting special ferrous and non-ferrous alloys, these materials being subsequently used for the manufacture of retorts and heat interchangers. He was appointed plastics group engineer in 1934 to supervise the design and erection of plant for the manufacture of urea-formaldehyde moulding powders. A year later, however, he became technical director of Henry Berry and Company, Limited, Leeds, with whom he was responsible for the production of high-pressure hydraulic equipment, tools and chemical plant. He was appointed joint managing director in 1952.

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We regret also to record the deaths of:

MR. PERCY RICHARDSON, O.B.E., at his home in Fulham, London, S.W.6, on October 8. Mr. Richardson, who was a pioneer motorist and had flown aircraft since the early days of aviation, was a director and late chairman of Foster, Yates and Thom Ltd., Blackburn, Lancashire.

Mr. H. D. WHEELER, B.Sc.(Eng.), which occurred on Monday, October 17, at the age of 68. He received his technical education at Glasgow University and, after being a pupil on the Midland and Great Northern Railway, joined the firm of Laurence, Scott and Company, Limited in 1909. He was appointed chief direct-current designer in 1920 and chief engineer in 1944, a post from which he retired only a short time ago.

MR. HUGH QUENTIN ALLEYNE REEVES, M.A., A.M.I.Mech.E., at the age of 46, on October 24, at Bitteswell airfield, Leicestershire. Mr. Reeves, a consulting engineer on heating and silencing problems, was investigating noise reduction from jet engines running on the ground for the Hawker Siddeley group. While carrying out tests on a Mark 5 Hunter with a Sapphire engine, he was drawn into the intake of the silencer and received fatal injuries.

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POWER REACTOR PROJECTS THROUGHOUT THE WORLD

Reprints of ENGINEERING Article

The demand for copies of the article "Power Reactor Projects throughout the World" (ENGINEERING, October 7), has been so large that reprints are now being prepared. The article was written by Mr. G. W. K. Ford, of the Atomic Energy Establishment, Harwell, and is believed to be the most comprehensive analytical and comparative treatment so far published.

Copies will shortly be available at 2*s.* 6*d.* each post free from The Publisher, ENGINEERING, 35 & 36 Bedford-street, Strand, London, W.C.2. On orders of 12 or more the rate will be 1*s.* 6*d.*

PERSONAL

SIR HERBERT MANZONI, C.B.E., M.I.C.E., M.I.Mun.E., engineer and surveyor of the City of Birmingham since 1935, has been elected chairman of the General Council of the British Standards Institution, 2, Park-street, London, W.1. SIR ROGER DUNCALFE has been re-elected President of the Institution and MR. JOHN RYAN, vice-president. SIR STANLEY RAWSON, vice-chairman of John Brown & Co. Ltd., has been elected chairman of the Institution's Engineering Divisional Council in succession to MR. S. J. HARLEY, whose term of office has come to an end.

Vickers Ltd., Vickers House, Broadway, London, S.W.1, announce that MR. E. L. CHAMPNESS, M.Sc., the managing director of the Palmers Hebburn Co., Ltd., is retiring on December 31 at his own request. It is also announced that VICKERS-ARMSTRONGS (SHIPBUILDERS) LTD. is acquiring as from January 1, 1956, the business of the PALMERS HEBBURN CO. LTD., Hebburn and Jarrow. The management will continue as at present and the establishments will be known as the Palmers Hebburn Works of Vickers-Armstrongs (Shipbuilders) Ltd.

DR. WILLIS JACKSON, F.R.S., director of research and education, Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester, 17, has had conferred upon him the honorary degree of Doctor of Technical Science at an academic ceremony in connection with the centenary celebrations of the Swiss Federal Institute of Technology, Zürich.

MR. F. THEAKSTON, O.B.E., M.I.Mech.E., M.I.Loco.E., a director of Robert Hudson Ltd., has now been appointed London director of the Hunslet Engine Co. Ltd., Hunslet Engine Works, 125 Jack-lane, Leeds, 10.

BRIGADIER G. E. BUTLER, C.B.E., has been appointed Inspector of the Royal Electrical and Mechanical Engineers as from April, 1956, with the rank of Major General. T/BRIGADIER R. B. STOCKDALE, O.B.E., has been made director of mechanical engineering, H.Q. Northern Army Group, as from February, 1956, and BRIGADIER S. R. W. CLARKE, deputy director of mechanical engineering (P), War Office, as from June, 1956. BRIGADIER D. S. RIDDELL, C.B.E., is to be deputy director of mechanical engineering, Scottish Command, as from December of this year and T/BRIGADIER K. G. LEGH-WINTER, deputy director of mechanical engineering, Southern Command, as from January, 1956.

MR. KENTON REDGRAVE, M.C., M.I.Mech.E., deputy chairman and managing director of Russell, Newbery & Co., Ltd., Dagenham, Essex, has been appointed chairman of the British Internal Combustion Engine Manufacturers' Association export committee as from November 1, in succession to MR. J. P. FORD.

DR. L. A. JORDAN, C.B.E., director of the Paint Research Institute of the British Paint Colour and Varnish Manufacturers' Research Association at Teddington, Middlesex, has left for India where he will stay for three months to advise the Government on the development of the lac industry. His visit has been arranged under the Technical Co-operation Scheme of the Colombo Plan.

MR. R. A. HENDERSON and MR. J. L. E. SMITH have joined the board of the Solartron Electronic Group, Ltd., Thames Ditton, Surrey.

MR. C. H. ASLIN, C.B.E., President, Royal Institute of British Architects, and MR. R. NICHOLAS, C.B.E., President, Institution of Municipal Engineers, have been appointed presidents of sections of the Royal Society of Health Congress, to be held at Blackpool from April 24 to 27. Mr. Aslin will be President of the Engineering and Architecture Section and Mr. Nicholas, president of the Engineers' and Surveyors' Conference.

The British Transport Commission have appointed MR. G. K. LUND to be assistant (motive power) in the operating and motive-power department, and MR. J. C. LOACH to be superindendent (vehicle and track division) in the research department, Derby. Both appointments are to British Railways Central Staff.

DR. J. S. CARTER, O.B.E., M.Sc., F.R.I.C., has been made chief inspector of alkali, etc., works in succession to MR. W. A. DAMON, C.B.E., B.Sc., F.R.I.C., M.I.Chem.E., who is retiring on December 4. Mr. Damon, however, will continue with the Ministry of Housing and Local Government in an advisory capacity.

MR. J. M. DELAPENA has been appointed home and export sales manager of Abwood Machine Tools Ltd., Princes-road, Dartford, Kent, in succession to MR. P. O. YOUNG.

BRIGADIER D. H. BOND, C.B.E., M.V.O., A.M.I.Mech.E., F.Inst.Pet., has been made mechanical and electrical engineer and stores officer, British Transport Waterways headquarters staff. He will be stationed at Birmingham.

MR. W. N. COLLINS, marketing director of F. Perkins Ltd., Peterborough, has been appointed to the Society of Motor Manufacturers and Traders' British manufacturers' committee to fill a vacancy for accessories and components manufacturers' representatives.

MR. J. L. THOMPSON, M.Sc., of Chicago, U.S.A., is to be manager of Square D Ltd., the London offices of which are at 100 Aldersgate-street, E.C.1, the newly formed British subsidiary company of the Square D Company, Detroit, particulars of which were given on page 592 of our issue of October 28.

Appointments made to the home sales staff of the Brush Electrical Engineering Co. Ltd., Loughborough, Leicestershire, comprise those of MR. R. D. TAYLOR as London branch manager, of MR. G. M. INGRAM as manager of the Sheffield branch office, and of MR. D. P. ENGERT as manager of the Ipswich branch office.

DR. L. E. COWART has been appointed agricultural service and development specialist, in Europe, of E. I. du Pont de Nemours & Co., Wilmington, Delaware, U.S.A. He will be based in Basle, Switzerland.

* * *

COMMERCIAL

As from November 1, the title of the Gas Division of THOMAS DE LA RUE & CO. LTD., Imperial House, 84–86, Regent-street, London, W.1, has been changed to the POTTERTON DIVISION.

THE CAPE ASBESTOS CO. LTD., of London and South Africa, have formed a company, CAPOSITE INSULATIONS LTD., for the manufacture of their asbestos thermal insulation materials in Canada. The new company has been established in association with HOLMES FOUNDRY LTD., Sarnia, Ontario, Canada. The marketing of the Caposite materials, in Canada, will be handled jointly by CAPE ASTESTOS (CANADA) LTD., Toronto, and the Industrial Insulation Division of Holmes Foundry Ltd.

A new trading arrangement has been arrived at between the AUTOMATIC COIL WINDER & ELECTRICAL EQUIPMENT CO. LTD., 92–96, Vauxhall Bridge-road, London, S.W.1, and BLUME & REDECKER, of Hanover, Germany, for the sale of the latter company's laminating, wire stripping and coil-winding equipment in the United Kingdom and Commonwealth markets and in China, Japan, Argentina and Russia and Russian satellite countries.

ACBARS LTD., Cecil House, 57A, Holborn-viaduct, London, E.C.1, have been appointed sole agents in the United Kingdom for the GRAFFENSTADEN range of milling machines.

MONSANTO CHEMICALS LTD., 8, Waterloo-place, London, S.W.1, have appointed HYGROTHERM ENGINEERING LTD., 37, Upper Brook-street, London, W.1. (Telephone: LEGation 4111) to be the sole agents in the United Kingdom for their organic silicate range of heat-transfer fluids.

The French shipbuilding and marine-engineering firms, CHANTIER ET ATELIERS DE SAINT-NAZAIRE (PENHOËT) ET ATELIERS ET CHANTIERS DE LA LOIRE have been re-grouped, as from October 1, to form two new companies, namely CHANTIERS DE L'ATLANTIQUE (PENHOËT-LOIRE) and SOCIÉTÉ DES CHANTIERS RÉUNIS LOIRE-NORMANDIE. The head offices of both companies are at 7, Rue Auber, Paris (9e). The former "Penhoët" and "Loire" companies have now become industrial and financial companies, namely, COMPAGNIE INDUSTRIELLE ET FINANCIÈRE DES CHANTIER ET ATELIERS DE SAINT-NAZAIRE (PENHOËT), 7, Rue Auber, Paris (9e) and COMPAGNIE INDUSTRIELLE ET FINANCIÈRE DES ATELIERS ET CHANTIERS DE LA LOIRE, 4, Rue de Téhéran, Paris (8e).

A new Anglo-American Company, POWER AUXILIARIES LTD., has been formed by the PLESSEY CO., LTD., Ilford, Essex, and the D.K. MANUFACTURING CO., Chicago, U.S.A., for the production of seamless flexible metal hose, termed "Plessiflex," for use in aircraft and fighting vehicles.

ALFA LAVAL CO. LTD., Great West-road, Brentford, Middlesex, inform us that their new modern factory at Cwmbran, Monmouthshire, has now been opened.

CANTIE SWITCHES LTD., announce the appointment of ROBERT GARMANY AND SON LTD., 33, Queen-street, Belfast (Telephone: Belfast 23811) as their agents in Northern Ireland and Eire. This is a newly-registered company under the managing directorship of MR. T. M. CALVERT to carry on the business of the late MR. R. GARMANY, who acted as agent for Cantie Switches Ltd. for many years.

The Midland branch office of the POWER PETROLEUM CO. LTD., Cecil Chambers, 76–86, Strand, London, W.C.2, has been moved to new offices at King Edward House, New-street, Birmingham, 2. (Telephone: Midland 8021–6).

THE NEVELIN ELECTRIC CO. LTD., a subsidiary company of LANCASHIRE DYNAMO HOLDINGS LTD., have moved to a newly-acquired factory on a 30-acre site at Hurst Green, Oxted, Surrey. (Telephone: Oxted 1450).

E. ELLIOTT LTD., moulders in plastics, have opened new modern offices at 315, Summer-lane, Birmingham, 19. (Telephone: Aston Cross 1156–9).

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CONTRACTS

Oil Tankers. The British Petroleum Co.'s shipping subsidiary company, the British Tanker Co. Ltd., has placed orders for 23 new tankers, totalling 836,000 deadweight tons. Of these 17 vessels, making together 629,000 tons, are to be built in United Kingdom shipyards and six, amounting to 207,000 tons, in Italy. The orders placed with British yards are given below, the tonnage figure in each case being for the vessel's deadweight carrying capacity. With JOHN BROWN & CO. LTD., Clydebank, two vessels each of 42,000 tons and one of 34,500 tons. With CAMMELL LAIRD & CO. LTD., Birkenhead, one of 34,500 tons. With the FAIRFIELD SHIPBUILDING & ENGINEERING CO. LTD., Govan, two each of 34,500 tons. With HARLAND & WOLFF LTD., Belfast, two each of 42,000 tons. With HAWTHORN, LESLIE & CO. LTD., Hebburn-on-Tyne, two each of 34,500 tons. With SWAN, HUNTER, AND WIGHAM RICHARDSON LTD., Wallsend-on-Tyne, three each of 34,500 tons. With J. L. THOMPSON & SONS LTD., Sunderland, one of 34,500 tons. With VICKERS-ARMSTRONGS (SHIPBUILDERS) LTD., Barrow-in-Furness, two of 42,000 tons and one of 32,000 tons (the contract for the latter to be taken over from another owner).

The Italian orders have been placed with ANSALDO, Genoa, and with CANTIERI RIUNITI DELL ADRIATICO, Trieste, which will each build three tankers of the 34,500-ton class.

The orders for the 23 ships are valued at a total of about £52 million, and negotiations are still proceeding which may result in the placing of several further orders. The ships are to be delivered during 1958 and 1959.

The new tankers will all be propelled by steam turbines which will provide an average service speed, when loaded, of 15½ knots for the 34,500-ton ships and 16 knots for those of 42,000 tons.

With the addition of the nine tankers at present under construction or previously ordered by the company—two each of 16,000 tons and seven each of 32,000 tons—the company's building programme now totals 32 ships, making together 1,092,000 deadweight tons.

Helicopters. An order for the supply of Dragonfly helicopters to the Royal Ceylon Air Force has been placed with WESTLAND AIRCRAFT LTD., Yeovil, Somerset. They will be the first helicopters to go into service with Ceylon's Air Force and are being shippped forthwith to Colombo for assembly on arrival.

Steel-Strip Processing Lines. Orders for stainless-steel strip processing and pickling lines to the value of about £900,000 have been placed with the WELLMAN SMITH OWEN ENGINEERING CORPORATION LTD., Parnell House, Wilton-road, London, S.W.1. Included in the total is a £200,000 contract for Sweden.

Jet Energisers. An order placed by the United States Air Force for a large number of jet energisers or ground power units, to be used for servicing and starting the jet fighter aircraft of N.A.T.O. Air Forces, is nearing completion at the Uxbridge Works of AUTO DIESELS LTD. The order, valued at 1¼ million dols., is being fulfilled in conjunction with CROMPTON PARKINSON LTD., and ROLLS-ROYCE LTD.

Television Station. The British Broadcasting Corporation have awarded further contracts to MARCONI'S WIRELESS TELEGRAPH CO. LTD., Chelmsford, Essex, for work on the Crystal Palace television station. These call for the erection of a 250 ft. mast, together with an aerial and feeder system, and for the design, construction and installation of a special catwalk. The latter is rendered necessary because, for technical reasons, the mast has had to be built in the middle of a disused reservoir. The catwalk will carry the feeders across to the base of the mast.

Book Reviews

THE CHURCH AND THE LABORATORY

Science and Modern Life. By SIR E. JOHN RUSSELL, F.R.S. *Epworth Press, 25 City-road, London, E.C.*1. (6*s.* 6*d.*)

In one short section of this reprinted lecture, Sir John Russell gives a hint of that high quality of thinking on the position of science in society of which he is capable. He briefly compares science with art and comes to the conclusion that whereas artistic achievement, being personal, may have reached its peak many centuries ago, science, being mainly joint work, grows by accretion: "Science starts from the simple and obvious, reaches out to the infinite, but can never hope to get there."

In face of this affirmation it is surprising that the remainder, which purports to demonstrate that the old conflict between science and religion is no longer valid, should be mainly a pessimistic recital of the present state of scientific and technical development and its supposed effect on society. Here, set out with neither scientific judgment nor Christian compassion, are cited all the symptoms of modern life about which those who complain see only the froth on the surface. Supported by quite inadequate references, Sir John parades the familiar jeremiad of social degeneration, growing strikes, destruction of the upper classes by taxation and declining birth rates, falling intellectual standards at the universities, lower moral standards, lack of responsibility and bad use of leisure by the masses, juvenile delinquency, accelerating consumption and waste of the world's raw materials, population growing faster than food supply. It all reads like some gloomy work of science fiction, occasionally offset by irrelevant and contradictory platitudes about the virtues of the British working people.

What is so extraordinary is that Sir John should not have applied some of his own scientific tests to the validity of his assumptions. He might have reminded himself that when he was a young man the articulate part of society was a tiny fraction of the whole population—like the top of an iceberg. To-day, with secondary education for all, universal franchise and full employment, the actions and outlook of the whole population are exposed to view. He contradicts himself when, discussing the future of psychology, he complains that our minds have developed little since the days of ancient Greece 2,500 years ago, when he has just reminded us that the universe has been estimated to be 6,000 million years old. Has he forgotten that most of the advances in physical science have taken place in the last three hundred years and the pace is accelerating? Has he never applied statistical tests to some of his judgments about the relative intelligence of the classes in society or the relative moral standards of this and previous generations?

In view of this attitude it is perhaps not surprising that he has little to say about the part science can play in solving the problems of our time; and little more of the part of religion, except as blind faith. In spite of his own faith, he obviously feels the dilemma in which a religious scientist is placed by the views of Churchmen such as the Archbishop of York, who has said that the proclaiming of scientific results is not always necessary or desirable: "Truth must be imparted according to the measure in which men are capable of receiving it and using it rightly." Sir John cannot accept this for it is impossible to stop the course of scientific discovery, and the scientist who makes an original discovery can rarely foretell to what it may lead. The truth is that, as long as anyone who purports to speak for the Church believes that there should be any limit either to scientific speculation, discovery or publication, the conflict between science and religion has not been finally resolved.

Magnetic Materials in the Electrical Industry. By P. R. BARDELL. *Macdonald and Company (Publishers), Limited, 16 Maddox-street, London, W.*1. (32*s.* 6*d.*)

Ever since Faraday, in his researches on the interrelation of electricty and magnetism, laid the foundations of the electrical industry magnetic materials have become of increasing concern to the electrical engineer. Until comparatively recently their range was restricted, and as the development of new materials had to be carried out largely on an empirical basis, with little in the way of reliable theoretical guidance, progress was slow and sporadic. The extension of modern physical concepts embodied in the theory of the solid state to magnetic materials has introduced revolutionary changes and it is now becoming feasible to produce materials of specified magnetic characteristics to meet new and increasingly exacting demands.

The author's aim in this book is "to bridge the gap between the academic study of the properties of magnetic materials and the limited treatment of the subject possible in most textbooks for engineers," and his main object is to link the properties of such materials with their applications. An endeavour is made, in the introduction, to clear away some of the confusion caused by changes in the names of the magnetic units proposed at four international conferences held between 1896 and 1950. In the theoretical considerations that follow, a broad outline is given of the Ewing molecular theory, the Weiss domain theory and its confirmation by evidence from the Barkhausen effect and the Bitter powder pattern technique, of the influence of crystal size and structure on magnetic properties and of the further advances due, among others, to Néel, Stoner and Bates. Permanent-magnet materials are next discussed with data tabulated to show how progressive increases in remanence and coercivity have been secured by means of different alloys and alloy and oxide powders the individual particles of which are comparable in size with the domain boundaries. Methods of magnetisation are also described and practical applications of permanent magnets in moving-coil instruments, electrical machines, loudspeakers, relays and magnetrons are considered.

Materials endowed with characteristics opposite to those desirable in a permanent magnet—that is, with as low a residual magnetism and coercivity as possible and as high a permeability as possible—are of equal, or even greater practical importance, and to them four chapters are devoted. In the first of these the composition, preparation and magnetic properties of commercially available soft magnetic materials, which include pure metals, alloys and the more recently introduced sintered ferrites, are dealt with in turn. In the second, measurements of permeability, hysteresis and eddy-current losses on soft magnetic specimens are described, with diagrams of the circuits concerned and indications of the order of accuracy attainable. Power frequency applications, considered in the third, include transformers, direct-current machines, relays and chokes, while communication frequency applications, which form the subject of the fourth, cover the loading and filter coils used in telephony, powder-cored coils suitable for use at radio frequencies and communication transformers.

Emphasis is laid, in the following chapter, on the basic physical principles involved in magnetic-tape recording, play back and erasing. The magnetic requirements and testing of recording wires and tapes are also discussed and mention is made of methods of duplication and the interesting development whereby magnetic powders are employed to record pictures.

Chapter 9 discusses, under two headings, non-destructive tests by magnetic means of the chemical, physical and mechanical properties of articles. The first comprises tests for detecting or measuring a discontinuity in a magnetic circuit, and normally involves measurement of reluctance or of leakage flux. The second includes tests for assessing the magnetic characteristics of a specimen, usually by a comparison of the specimen's permeability, hysteresis, or more rarely of its induced eddy-current loss, with that of a reference specimen. Representative commercial instruments in both classes are described and illustrated. The general principles of operation and the mode of construction of magnetic amplifiers are considered briefly in Chapter 10, and the advantages and limitations of this type of circuit component are pointed out. The text concludes with an indication of the important part played by magnetic materials in electro-mechanical transducers.

A glossary of terms, a list of magnetic units and a selection of references after each chapter add to the usefulness of a volume that should be welcomed by electrical engineers.

STEEL CASTINGS CENTENARY

The present year marks an important centenary in the history of the English Steel Corporation, Limited, Sheffield, 9, and of the British steel industry. In 1855, after a visit to Germany, Colonel Tom E. Vickers, son of one of the early pioneers of the organisation, introduced to Great Britain a method of making steel castings which a steel founder of Bochum, Westphalia—Jacob Meyer—had discovered the previous year. At the old Millsands Works in Sheffield, belonging to Naylor, Vickers and Company, an early precursor of the English Steel Corporation, Colonel Vickers, who had been appointed works director at the early age of 23, began casting Britain's first steel cog wheels and railway crossings, using a moulding compound eventually known as "Sheffield Compo," made of calcined fireclay obtained from old crucible melting pots, mixed with a small quantity of new clay to make it plastic.

His most notable venture, however, was the production of steel bells, over 7,000 of which weighing up to 7½ tons had been produced by 1880. Many of these went to the United States and others were sold as far afield as Russia, New Zealand, Syria and West Africa. Chimes and peals were also supplied to the South Kensington Museum, the Glastonbury astronomical turret clock, Knaresborough Town Hall and St. Giles's Cathedral, Edinburgh. Bell founding was discontinued by the company before the end of the Nineteenth Century, but not before heavier steel castings, such as ships' propellers and structural and other marine castings, had taken their place.

Since then, the company has developed its foundry into one of the largest and most modern in Great Britain, and at the present time the Grimesthorpe Works of the English Steel Castings Corporation, Limited, one of the subsidiary companies of the parent firm, produce steel castings ranging from a few ounces up to 185 tons. Particulars of the latest large steel casting produced by the firm were given on page 487 of our issue of October 7. Another casting recently dispatched from the works constitutes the first of a series of one-piece cast-steel three-axle truck beds for forty New South Wales Government Railways 3,820 h.p., 0—6 + 6—0 electric locomotives, which Messrs. Metropolitan-Vickers-Beyer-Peacock, Limited, are building at their Stockton-on-Tees Works, and for whom the English Steel Castings Corporation are the sub-contractors.

Measuring nearly 25 ft. in length, by 8 ft. in width, and weighing approximately 7½ tons, the truck beds are of heat-treated steel and are designed to carry three 1,500-volt force-ventilated motors driving the axles. The locomotive superstructure is carried on a pair of the truck beds joined by means of a special articulation coupling and the rail load per axle is 18 tons.

BOOKS RECEIVED

Some of the books noticed here are selected for extended review in ENGINEERING.

Studies in Composite Construction. Part II: The Interaction of Floors and Beams in Multi-Storey Buildings. By R. H. WOOD. National Building Studies Research Paper No. 22. Published for the Department of Scientific and Industrial Research by *H.M. Stationery Office, Kingsway, London, W.C.2.* (5*s.*)

The Building Research Station is making a full study of the complex behaviour of composite structures and the present paper (the second in the series) is concerned with the interaction of floors and beams in multi-storey buildings. It is concerned with the effects of interaction and, after an introduction, proceeds to develop a detailed theory, dealing firstly with working (elastic) conditions and then with the mechanism of ultimate collapse of composite beam-slab systems. It is established that walls and floors can be as important in resisting distortion as the frame itself and the paper attempts to deal with fundamental principles governing the behaviour of composite floor and beam systems, giving special attention to the conditions existing at the junction between the floor slabs and the supporting beams.

The Machine Boring of Wood. By R. GOODCHILD. Forest Products Research Bulletin No. 35. Published for the Department of Scientific and Industrial Research by *H.M. Stationery Office, Kingsway, London, W.C.2.* (2*s.* 6*d.*)

In wood-boring operations, the power demand and quality of the finish produced depend on the shape and dimensions of the bit, the feed speed and the cutting speed. The report describes tests carried out on various species of hardwood and softwood to determine the relationship of these factors and their effect on the service life of the tool.

Fuel Consumption in Schools. Ministry of Education Building Bulletin 13. *H.M. Stationery Office, Kingsway, London, W.C.2.* (2*s.*)

Most schools are only occupied for about 40 hours out of the week of 168 hours; although exaggerated, this condition is not far removed from that in smaller factories where a single day shift is worked. Because of the intermittent nature of heating required in schools the Ministry of Education requested the Building Research Station to undertake an investigation to determine the most economical method of heating. Three different types of heating were studied: forced warm air, radiators and floor panels, and the relative order of economy was found to be in that order.

Land, Water and Food: A Topical Commentary on the Past, Present and Future of Irrigation, Land Reclamation and the Food Supplies They Yield. By HERBERT ADDISON. *Chapman and Hall, Limited, 37 Essex-street, London, W.C.2.* (18*s.*) (Reviewed on page 560, in the issue of October 21.)

The following reports may be obtained from the British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking-road, Leatherhead, Surrey:—

The Influence of Phase Number of a Convertor on Harmonics. By F. BUSEMANN. No. B/T117. (10*s.* 6*d.*) This report discusses the limits imposed on the minimum phase number of a convertor by the harmonics set up in the a.c. system. The amount of harmonics is in turn restricted by communication interference and by disturbance of equipment in the a.c. system itself. The mitigation provided by parallel capacitance is taken into account. Figures are given for the special cases arising in the proposal to use d.c. transmission in the cross-channel link.

On the Theory of Dielectric Breakdown in Ionic Crystals—II. By B. V. PARANJAPE. No. L/T285. (6*s.*) Fröhlich has recently applied to pure crystals the method of calculating the breakdown strength previously developed for amorphous substances. In this method the electrons are considered to be in thermal equilibrium at a temperature higher than the lattice temperature. These ideas have been carried through in a more accurate way.

The Variation with Temperature of the Electric Strength of Polyisobutylene Subjected to Discharges. By E. M. HAWLEY. No. L/T290. (10*s.* 6*d.*) This report describes tests on the electric strength of polyisobutylene. Experimental techniques and results are given together with conclusions drawn from the results.

The Dispersion Meter. Design and Development. By G. MOLE. No. V/T121. (18*s.*) This report covers the design and development of a portable electronic instrument which measures directly the dispersion and leakage time constant of insulation of all kinds within the capacitance range of 70 pF to 0·35 μF, and gives readings which are immediately significant.

Dispersion Meter, Model 2. Instruction Manual. No. V/T124. (10*s.* 6*d.*) The basic principle of the instrument, the design of which is described in Report V/T121, is first given, followed by detailed instructions for calibrating and using it. Calibration circuits for dispersion and for leakage time constant are given, together with a method for checking the calibration periodically.

The Effect of Surface Material, Surface Finish, Temperature of Operation and Water Composition on the Deposition of Carbonate Scale on Electric Immersion Heaters of High Specific Loading. By M. V. GRIFFITH and H. M. BROWNING. No. Y/T16. (15*s.*) The report describes investigations which have been carried out under laboratory conditions to find a short-term solution of the problems arising when electric immersion heaters are used in hard-water areas.

A Pressure Chamber for Micro-Optical Observations. By C. TURNER. No. L/T283. (7*s.* 6*d.*) The report describes the construction and performance of an apparatus for optical observations at pressures up to 1,000 atmospheres. It permits the measurement of changes of transition temperature with pressure, and can be used to derive heats of transition on small samples, and it can also be used for moderately long-lived unstable structures.

Information Processing Equipment. Edited by M. P. DOSS. *Reinhold Publishing Corporation, 430 Park-avenue, New York 22, N.Y., U.S.A.* (8.75 dols.); and *Chapman and Hall, Limited, 37 Essex-street, London, W.C.2.* (70*s.*)

At the September, 1953, meeting of the American Chemical Society in Chicago, a symposium entitled "Equipment for the Preparation, Reproduction and Utilization of Technical Information" was presented before the Division of Chemical Literature. This symposium was accompanied by an exhibition of the equipment itself. This book presents ten papers delivered at the symposium, with photographs and descriptions of the equipment exhibited. The subject matter includes: lensless copying with sensitised papers; photography in the laboratory; micro-copying; letterpress and offset printing; audio methods for handling data; storing and finding technical information with punched cards; and numerical data-handling machines.

Durability of Aggregates in Concrete Mixes (Final Report). By R. H. PICHER. Memorandum Series No. 129. *Department of Mines and Technical Surveys, Mines Branch, Ottawa, Canada.* (50 cents.)

This publication is a comprehensive report of a long-term investigation of the properties of concrete aggregate from rock deposits in eastern, southern and western Ontario. The tests were originally planned to provide information for the selection of suitable local material for aggregates in connection with the proposed waterway and power development on the St. Lawrence River in eastern Ontario. It was later extended to include materials from southern and western areas of the province, this being undertaken at the request of commercial producers of crushed stone in the areas.

Taschenbuch für Heizung und Lüftung, 1955. Edited by EBERHARD SPRENGER. *R. Oldenbourg Verlag G.m.b.H., Rosenheimer Strasse 145, Munich, Germany.* (32 D.M.)

This heating and ventilating manual is now in its 48th edition. Up to 1944 it appeared annually as "Recknagels Kalender für Gesundheits- und Wärmetechnik" but since then it bears the title shown above and is not necessarily issued yearly. The contents are drawn up to provide advice and guidance for the practical heating and ventilating engineer, and with this object in view the text is adequately illustrated by 521 diagrams and 292 tables, as well as an appendix providing references to official regulations, standard specifications, other literature on the subject and information on related trade associations, etc. The first part is devoted to tables and graphs relating to the principles of heating and ventilation and these include meteorological and hygienic considerations followed by the principles of heating, flow and acoustics. The second part deals with heating systems, their component parts, calculations, installation in different types of buildings and matters of co-operation between architect and builder in relation to provision for heating. The third part is devoted to ventilation and air conditioning and to the systems, plant, equipment and calculations appropriate thereto as well as suitable planning by architect and builder. The fourth and fifth parts cover, respectively, hot water and industrial exhausting installations.

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

The Electrical Industry. GENERAL ELECTRIC CO. LTD., Kingsway, London, W.C.2. Some aspects of the present state of and the future outlook for the electrical and electronic industries, described in a series of short surveys of topics in which the company has a specialist interest. Subjects include the influence of atomic power on the future generation of electricity; the growth of automation in industry; inter-city dialling in telecommunications; railway modernisation; new materials; and education for leadership. Illustrated booklet.

Domestic Solid Fuel Appliances. COAL UTILISATION COUNCIL, 3 Upper Belgrave-street, London, S.W.1. Open fires, intermittent, and continuous-burning, with and without boilers; heating stoves with and without boilers, cookers, combination grates and independent boilers; appliances recommended by the C.U.C. and Solid Smokeless Fuels Federation. Booklet giving lists of appliances, manufacturers, and suitable fuels; list number 11, July, 1955.

Transformers and Chokes. WESTOOL, LTD., St. Helen's Auckland, Co. Durham. Functions and mechanical features of range of single-phase transformers up to 5 kVA and three-phase transformers up to 18 kVA. Also single-phase and three-phase transformers for frequencies up to 2,000 cycles, iron-cored chokes, audio transformers, power packs and rectifier units. Technical data sheets.

Friction Clutch. LINK-BELT COMPANY, 307 North Michigan-avenue, Chicago, Illinois, U.S.A. Toggle-operated friction clutch, with three different mountings, to suit various methods of power take-off. Capacities up to 170 h.p. at typical industrial speeds. Illustrated booklet, with h.p. and dimension tables and clutch-selection data.

Vacuum Coating Plant. EDWARDS HIGH VACUUM LTD., Manor Royal, Crawley, Sussex. Plant for metallisation by vacuum technique. Three models, 12EA with work chamber 12 in. diameter by 14 in. high (leaflet E 101/5) and models 6E and 6ES (shadow casting) with work chambers 6 in. diameter and 8½ in. high (leaflet E 108/5).

Voltage Regulators. FOSTER TRANSFORMERS LTD., South Wimbledon, London, S.W.19. Equipment for voltage control and regulation. Models for handling up to 45 amperes and 50 kVA per phase. Also electronic and electromagnetic automatic control units. List No. 4300 (second edition).

Fork Lift Truck. RANSOMES, SIMS AND JEFFERIES LTD., Orwell Works, Ipswich. Battery-operated fork lift truck FL 2000; capacity (British rating), 2,000 lb. at 20 in. centres. Low collapsed mast height; turning radius 71 in. Battery rating, 375 ampere-hours. Illustrated descriptive leaflets.

Constant Voltage Transformer. FOSTER TRANSFORMERS LTD., South Wimbledon, London, S.W.19. Constant voltage transformer with electronic control. Input between 210 and 250 volts with a variation of ± 35 volts, between 40 and 63 cycles. Maximum load 500VA output voltage with ± 0·25 per cent. of nominal input. List 4210.

Smaller "Traxcavator". CATERPILLAR TRACTOR COMPANY, Peoria, Ill., U.S.A. Traxcavator (combined tractor and excavator) No. 933 has 1 cub. yd. bucket and 50h.p. engine. Smaller version of the 955. Leaflet.

Tool Bit Holder. JAMES NEILL & CO. (SHEFFIELD) LTD., Napier-street, Sheffield 11. "Eclipse" toolholders, two sizes for tools from $\frac{5}{16}$ in. to $\frac{1}{2}$ in. and from $\frac{5}{16}$ in. to $\frac{3}{4}$ in., and three styles, right hand, left hand or straight. Leaflet No. 34.

Electrical Accessories. M.K. ELECTRIC LTD., Wakefield-street, Edmonton, London, N.18. Information and price list of socket outlets and plugs, switches and bell pushes and cooker control units of many types. Illustrated booklet.

Diesel Locomotives. ANDREW BARCLAY, SONS & CO., LTD., Caledonia Works, Kilmarnock. Diesel locomotives up to about 400 h.p. with mechanical, electrical or hydraulic transmission. Booklet illustrates and describes ten typical examples.

Automatic Oil Burner. PRIOR STOKERS LTD., 1-3 Brandon-road, London, N.7. Automatic emulsifying oil burner for 200 seconds (Redwood No. 1, 100 deg. F.) oil. Heat release 1 to 2 million B.Th.U. per hour. Driven by a 1h.p., 3phase motor. Leaflet.

Oil Production. PETROLEUM INFORMATION BUREAU, 29 New Bond-street, London, W.1. Coloured wall map, 30 in. by 40 in., showing world oil production figures for 1954. Price 2*s.*

DEVELOPMENTS IN LOW-HEAD HYDRO-ELECTRIC STATIONS

*By Maurice Gariel**

It is natural that the initial steps taken to harness water power were directed to the simplest and most economic arrangements possible at the time, bearing in mind the stage of technical advancement then reached. Thus, for many centuries, mills have used heads of a few metres only and low horse-power ratings. With Fourneyron's invention of a hydraulic machine adapted to suit factory requirements, it became possible to utilise heads of some tens of metres and to obtain several hundred horse-power. Berges succeeded in harnessing falls of, first, 200m., and then 400m. by selecting sites where streams fell so steeply that the length of the supply and discharge channels and conduits was reduced to a minimum. The quest for such sites was one of the first aims of the pioneers of "White Coal," their object being maximum changes in levels for given horizontal distances.

Obviously, the higher the head the greater the energy in a given quantity of water, and the more economical the hydraulic machinery itself; moreover, stores of energy are more effective if developed at high altitudes. For these reasons, the first large power installations were operated under high and medium heads.

However, in 1892 the Jonage station proved the advantage to be gained by using the Rhône at Lyons, even with a head of only 12m.; but the cost per installed kilowatt at Jonage remained a record high figure which, for a long time, had a deterrent effect on the use of low heads. This, however, did not prevent the construction of progressively more and more powerful installations of this type in all the industrial countries, resulting in technical improvements of which this same Jonage plant became a striking example in 1935. The plant was initially equipped with ten 1,250 h.p. generators, but in 1935 it was found possible to install, in the original water chambers, turbines developing more than 6,000 h.p. each.

This great progress in the utilisation of a given volume of masonry depended essentially upon the evolution of the design of turbine runners (which led these to become propellers) and, finally, upon the problem of enormously increasing the flow capacity of a given orifice by providing a draft tube capable of recovering the kinetic energy in the water flowing through the orifice. Similar improvements have now been made at the Tuiliere plant on the Dordogne, where Electricité de France have installed turbines of 7,000 h.p. in the original chambers, built in 1907, which formerly contained 3,100 h.p. machines.

From this can be seen the considerable influence of the evolution of technique upon the cost of power stations using low heads. Moreover, considerable progress is being achieved in this same field as the result of later inventions, largely those of French engineers. In the field of engineering technology which is concerned with high-power standard vertical-shaft turbines, mention may be made of the alternator-rotor turbine-runner linkage consisting of an assembly of annular, cylindrical or conical parts, mounted telescopically and arranged so that the lateral bearings can be dismounted to the side.

This arrangement reduces, or completely obviates, the use of the enormous forged-steel shafts employed in present-day units and results in a turbine which is extremely compact vertically; its component parts are also reduced in height, with the consequent advantage that the hook of the overhead crane has a shorter vertical rise. Thus there is a considerable saving on the alternator room of the generator station, as this simply becomes a covered way for the crane paths, which can be much lower; there is even the possibility of eliminating this room altogether.

HORIZONTAL-SHAFT AXIAL TURBINES

This development is governed by three ideas, namely, reverting to the more or less axial type of reaction propeller turbines, like the Jonval turbines of a hundred years ago, but with suitable runners and distributors having either fixed or adjustable guide-vanes; designing the diffusers to be as straight as possible or, in any event, to have only the slightest curvature; and designing the entire units with horizontal or slightly inclined shafts and, with this in mind, finding new ways of assembling and constructing alternators suitable, under the most economic conditions, to be driven by such axial flow turbines.

It was probably the late Mr. Leroy H. Harza, the well-known American consulting engineer, who, in his 1919 and 1924 patents, first proposed an installation on the above principles; he also fitted the runner with a ring on which the alternator poles were mounted, so that the alternator stator surrounded the turbine runner. This idea was exploited in Germany under the Hitler régime and resulted particularly in the Arno Fischer plants in Bavaria.

As long ago as 1927, however, the French group studying the alterations to be made to the Aswan Dam had suggested using inclined-shaft axial turbines so as to utilise the advantages of the slightly-curved draft tube while raising the alternator above the upstream level. Tests on scale models were then undertaken by Neyret-Beylier and Piccard-Pictet (now "Neyrpic") and these demonstrated the qualities of this type of turbine, though the efficiency did not exceed 83 per cent.

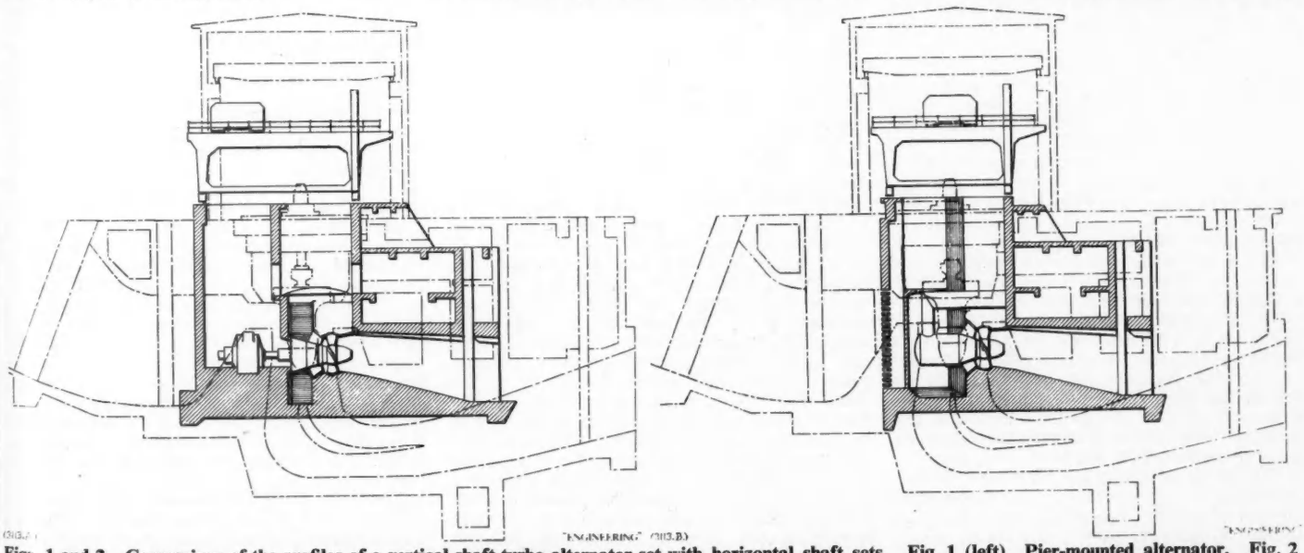
It was during investigation into the use of tidal energy, undertaken in France first of all by the Société pour l'Etude de l'Energie des Mers and then by Electricité de France, that the 1927 ideas and test were reviewed and finally led to remarkable results. In this way the efficiency of axial turbines determined on a model with runners 314 mm. in diameter reached 91 per cent. with a general layout known as a "pier unit," which permits the use of a standard alternator and is therefore absolutely reliable. A power station so designed, using horizontal shaft pier units, and without any undue risk from either the hydraulic or the electrical point of view, results in remarkable economy, both as regards the actual machinery and the civil engineering work involved.

Before enumerating these savings, it may be pointed out that the horizontal shaft arrangement avoids using very high-powered units; on the other hand, it increases the number of units in a given plant. This is clearly a reversal of the present trend, but it is, in fact, technically necessary. Such a reversal of practice is necessary both for mechanical reasons and because of cavitation phenomena occurring at the upper part of the runners. In actual fact, this increase in the number of units—which may seem surprising at first—is generally found to be highly advantageous.

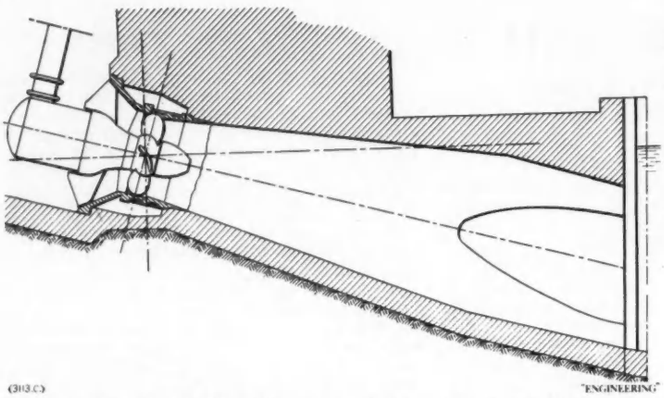
Firstly, if so desired, it allows the use of particularly simple and economical turbines, with fixed distributors, for river power plants, nevertheless utilising varying flows and heads under excellent conditions of efficiency. Moreover, distributors with adjustable guide-vanes may easily be used if it is desired to attain the highest productivity. Furthermore, the foundations required are remarkably shallow and the resulting advantage is easily discernible when structures are built in a river. The disadvantages of the extra electrical equipment practically disappear when set against these advantages. All in all, the hollow-pier axial unit layout can be said to result in an immense saving when the whole installation is considered.

This saving is obvious from an examination of Fig. 1 in which the cross-sectional elevation of

* President and Director General of the Etablissements Neyrpic, Grenoble, France.



Figs. 1 and 2 Comparison of the profiles of a vertical shaft turbo-alternator set with horizontal shaft sets. Fig. 1 (left) Pier-mounted alternator. Fig. 2 (right) "Bulb" fluid-cooled alternator. Eight horizontal sets give the same output as three vertical ones and occupy the same length of building.



(3113.C) "ENGINEERING"

Fig. 3 Fluid-cooled monobloc turbo-alternator set with inclined axis as installed at the Castet power station of the S.N.C.F. The output is 1,100 h.p. at 250 r.p.m. under a head of 7·8 m.

the normal vertical shaft station covers 1,800 sq. m., which is reduced to 600 sq. m. when using pier units. The diagram shows a 60,000 h.p. generating station operating under a head of 8·20 m., actually equipped in one case with three standard units and three flood sluices at the side and, alternatively, with eight new-style units, i.e., with axial propeller-type turbines in which the propellers are provided with adjustable blades, with fixed guide vanes and flood sluices located between the units. The total length of the station is more or less the same in both cases.

With the flow variability experienced in the great French rivers, the output in kilowatt-hours is about the same with both arrangements. On the other hand, with regard to the civil engineering side of the project, the volume of earth excavated and the quantities of concrete to be handled are reduced to such an extent that the cost of the civil engineering work alone is reduced by about one-third. The turbines weigh over 40 per cent. less, and the weight of the alternators is also reduced to a very great extent. Taken as a whole, the saving on the cost of the entire power station is in the region of 25 to 30 per cent. A similar saving is found in the majority of cases where this new system is adopted.

If the power station also constitutes the dam itself and therefore the entire outlay, the above percentage fully applies to the installed cost per kilowatt-hour for the whole installation. For example, this is precisely the case with the Wadrineau plant which the Metz Municipal Régie is proposing to equip with four pier units of 2,020 h.p. operating under a head of 4·60 m.; in this case, the station forms part of the dam.

MONOBLOC FLUID-COOLED UNITS

Among the other schemes which also use axial turbines, there is one in particular which seems to be particularly worthy of attention. It concerns those units using alternators in bulbs or "bulb units" in which the alternator is integral with the turbine, and in which the rotor runs in oil or compressed gas; the circulation of the fluid in which the rotor operates transmits the heat generated to the wall of the stator bulb, which is itself immersed in the water. An attempt to build a generator of this type was made in Germany some 15 years ago but, according to the published results, the alternator finally succeeded in supplying only a fraction of the power for which it had been designed.

As a result of the ideas put forward and the systems invented in 1949 by M. Guimbal, Professor of Electrotechnical Studies at the Saint-Etienne School of Mining, and thanks to a whole series of mechanical improvements, it has been possible to put new designs on a practical footing; this is the case in particular with the French Railways' Castet power plant, using two bulb units of 1,100 h.p. under a 7m. head, and equipped with axial turbines and asynchronous generators operating in oil.

The first of these units has been tried out on a test bench or, more correctly, in an "aquarium," for the purpose of checking that the means applied to provide perfect circulation of the coolant were operating as expected; this was done by carefully interpreting the temperatures at many points on the asynchronous generator. The research undertaken, and the electrical and hydraulic tests effected, have made it possible to start investigating the construction of larger designs with full confidence.

The Castet power station, one unit of which is shown in Fig. 3 above, was put into service in August, 1953, and the operating conditions, both electrical and hydraulic, appear to be entirely satisfactory; they have even provided considerable excess power. A particularly advantageous feature of these units is the ease with which they can be placed in position. When the first Castet unit was installed, only ten hours elapsed between the time at which the work of lowering the "block" was started and the end of the job.

The arrangement with bulb units provides a cross-section which is still smaller than with the pier units, as can be seen in Fig. 2 on page 627. The area falls from 600 sq. m. to 540 sq. m. approximately, the overall length of the power station remaining the same. All other things being equal, the civil engineering work, which had been reduced by about one-third through the use of the pier units, is here reduced by some 40 per cent.; and the weight of the bulb is about 50 per cent. less than that of a standard Kaplan turbo-alternator.

It is evident, therefore, that this development offers very large savings on the cost per kW of low-head power plants. The research work now under way, and tests in power stations now being built, will make it possible to determine the maximum power at which it will be possible to utilise bulb units. It is already possible to point to the very interesting advantages the latter offer for equipping "micro-stations" like those being built by Electricité de France. Of two power plants on the Mayenne, one has a straight-line horizontal draft tube, and the other has one that is straight, but inclined, forming a syphon so that it is possible to dispense with all gates.

As these machines are installed in already existing channels, these small plants can operate with a very low head in which the mean cost per kWh over a year is extremely favourable. As many sites in France lend themselves to this form of installation, it will be seen that equipping them offers considerable possibilities.

The Maignannerie power station has been running since December, 1953, and gives complete satisfaction; the Ame power station was started up in the spring of 1954 and has proved to be equally satisfactory. At the other end of the powerscale, the Etablissements Neyrpic are building a 9,400 h.p. bulb unit to work with a head of 10·75 m., for the Cambeyrac power station on the Truyère, a 20,000 h.p. bulb unit with a head of 16·80 m. for the Argentat power station on the Dordogne, and a 12,000 h.p. bulb unit with a head of 10·5 m. for the Beaumont-Monteux power station. All these three are experimental Electricité de France stations. It can thus be seen that new perspectives are being opened to those, throughout the world, whose interest it is to equip hydro-electric power stations.

NUCLEAR POWER STATIONS

C.E.A. Names First Two Sites

The Central Electricity Authority has now named the sites on which it proposes to build its first two nuclear power stations. They are at Bradwell at the mouth of the River Blackwater in Essex and at Berkeley on the Severn Estuary in Gloucestershire. Subject to the approval of the sites by the Local Planning Authorities and the Minister of Fuel and Power, it is planned that construction of the stations will begin in 1957, and they should be contributing to public electricity supplies by 1960 or 1961. Each station will provide two to three times the power to be generated at the Calder Hall station of the United Kingdom Atomic Energy Authority, where electricity is only a by-product.

HEAVY COOLING-WATER DEMANDS

The search for sites was begun by the Authority immediately after the publication in February of the Government White Paper outlining the programme of nuclear power development. It was realised that great efforts would be necessary to carry out adequate investigations in time to give the programme a good start. The technical requirements of nuclear installations are complex and introduce novel problems in addition to those met in building orthodox power stations. Geological and foundation conditions are of special importance, since the reactors and their shielding impose unusually heavy site loads. Moreover, cooling-water requirements are substantially larger than for conventional stations of the same capacity.

On the other hand, nuclear power stations need comparatively small quantities of fuel and therefore large-scale transport facilities, such as have to be provided for coal and ash handling at ordinary thermal power stations, are not required. In consequence, since fuel cost is virtually independent of location, it is economically advantageous to build nuclear power stations in areas where normal fuels are expensive. They should be near to centres of heavy electrical demand or to places where the grid system can readily absorb their output, so that they can be run continuously day and night in order to obtain the maximum production for the heavy capital investment involved.

AIR SURVEYS

The search for sites involved large geographical areas, and to speed up the investigations many potential sites and their surroundings were surveyed from the air. Ground inspections were made of the more promising areas and data were assembled on the many factors affecting the suitability of the various sites. Consultations were also necessary with the Atomic Energy Authority, the Defence Authorities and others. Consideration of all the factors finally led to the selection of Bradwell and Berkeley as the best sites for the first two stations.

The type of reactor to be installed in the early stations in the Authority's programme is inherently safe. The heat generated in the reactor is absorbed by coolant gas. The hot gas is piped to separate heat exchangers where steam is raised to drive turbo-generators of conventional type.

Comprehensive precautions will be taken in the design of the reactors and ancillary plant to ensure the effective containment of all radio-active materials, not only in normal operations, but in every foreseeable contingency. Irradiated fuel elements will be transported in shielded containers to the Atomic Energy Authority's processing plants. There will be no chimney emissions as from the combustion of coal and hence the stations will contribute to the clean air policy. As foreshadowed in the White Paper, the Authority has selected sites for its first stations away from built-up areas.

The White Paper programme covers the construction of 12 nuclear power stations to be built and brought into commission by 1965, providing a generating capacity of 1,500 to 2,000 MW.

The Institution of Naval Architects Autumn Meeting (continued from page 601)

A YUGOSLAV SHIPYARD

SHIPBUILDING AND REPAIR AT ULJANIK

At the third technical session of the Institution of Naval Architects' Autumn Meeting in Yugoslavia, held in the morning of September 21, two papers were presented, the first of these dealing with "Organisational Developments of the Uljanik Shipyard." The author of the paper, Ing. Djuro Stipetic, technical director of the shipyard which he described, was unable to deliver it in person, being absent on business elsewhere. The paper was therefore presented by the production manager of the yard, Ing. Vinko Jamnicki. The chair was taken by Mr. Norman M. Hunter.

ORGANISATION OF THE ULJANIK SHIPYARD

The shipbuilding and repairing establishment now known as the Uljanik shipyard, the author explained, was formerly the Austrian naval dockyard at what was then known as Pola and now as Pula. Between the two World Wars it was divided into two parts, the portion on the mainland becoming an Italian naval dockyard and the other part, on an island, a private yard. In the second World War, about 70 per cent. of the combined establishment was destroyed, and the subsequent reconstruction, which began in 1947, shows little trace of the original layout. At that time it had retained only about 430 employees, but with these as a nucleus, and a new management, production was restarted and a training scheme instituted for the new personnel brought in from other districts, many of whom came from other industries. In 1948 the number of employees rose to 1,539, in 1949 to 2,793, and in 1950 it reached a peak figure of 3,415. The present number, it was stated, is 2,550. There are three building berths and three dry docks, an extensive provision of fitting-out quays, and all the necessary machine and other shops, etc., to undertake both new construction and repair work, and also the construction of Diesel engines. A portion of the establishment is devoted to the manufacture of welding sets and other products. About 60 per cent. of the projected work of reconstruction has been completed. Of the resources now available 70 per cent. is employed on new construction and 14 per cent. on repair work.

The greater part of the paper consisted of a description of the administrative organisation. Management is in the hands of a workers' council of 100, elected from the whole staff of employees. The Council elects from among its members an executive committee of ten, of which the managing director is an *ex officio* member. He acts in collaboration with the technical, financial and commercial directors and the secretary in dealing with current operational problems, and is responsible to the Government and to the City Council of Pula in matters of law and of the regulations applicable to the industry. He can suspend any decision of the workers' council or the executive committee which may appear not to be in accordance with existing laws and regulations. The paper contained a diagram of the "family tree" type, showing the further subdivisions of management among the different departments.

Instructor Rear-Admiral Sir Arthur E. Hall, K.B.E., who opened the discussion, observing that the yard had a chemical and testing laboratory, asked whether any provision was made there for research work. He noted, too, that the training schools came into the secretary's department, and inquired whether it was the intention to educate as well as train the young workers who were coming along.

Mr. J. D. Calder remarked that, under the heading "financial director" in the organisation chart, there was an item "liquidation." He suggested that this term might be explained more fully. Those who, like himself, had seen the Uljanik shipyard would certainly not expect it to go into liquidation; it was a most efficient yard. No one who had not seen the country as it was several years ago could really appreciate the immense amount of hard work which had been done in getting back into production.

Mr. J. A. Milne, C.B.E., suggested that some reference to the berthing accommodation, the output of ships and machinery, and a description of the welding equipment would add to the value of the paper. The organisation chart showed that there was a legal adviser. Was he a permanent employee, and if so, could he not be incorporated in the person of the financial director? The chart seemed to indicate heavy overhead charges, and that might be one way to reduce them.

Sir Victor G. Shepheard, K.C.B., asked what were the precise functions of the executive committee? On what types of questions did they decide? It had been said that the committee did not interfere with the general running of the yard. The British members in particular would be very interested to know precisely what they did do.

Mr. J. Foster Petree asked how often the workers' council met. It was a fairly big council, comprising 4 per cent. of the personnel of the yard. Did the members meet merely to elect their executive committee, or did they also meet at regular intervals to supervise the work of the executive committee?

Mr. R. B. Shepheard, C.B.E., B.Sc., noted that the sales division was one of the responsibilities of the work preparation and sales manager, which seemed unusual. It had been stated that, at an earlier stage, the sales division had been under the authority of the commercial director. Perhaps Mr. Jamnicki could explain more fully why that division, which had the extremely important functions of seeking new work, arranging contracts, etc., was a part of the work preparation division, under the authority of the technical director. Mr. Shepheard asked also for some further information on the organisation of training and schools. The paper showed that, in the equipment of the yard, there was provision not only for a very high percentage of new construction, but also for repairs, and that Diesel-engine production was starting; there were also facilities for testing anchors and chains and X-ray testing equipment. Any further details of this equipment that could be given would be very helpful. Technical inspection was shown as a separate subdivision under the technical director, and was independent of the production manager; that seemed an excellent arrangement, as the technical inspection was not subject to any kind of pressure by the production manager.

POST-WAR DIFFICULTIES

Professor Ing. S. Silovic thought that Mr. Jamnicki, in presenting the paper, did not emphasise sufficiently the condition of the yard in 1948. For about two years after the war it was occupied by Allied forces; although the country was free, it was poor, and in those two years the yard was practically evacuated. All the best men had left, practically all the naval architects and engineers had left, and those who remained were mainly the older workmen. One of the things they did at that time was to centralise all the yards under one general management. His own view was that that organisation was rather too American, but they had to arrange the organisation according to the conditions prevailing. The yard had been very largely destroyed during the war. When it was started again, one of the difficulties was that many of the workmen spoke only Italian. A minority of those at Uljanik were Italian and they were good workers. On the other hand, there were naval architects and engineers who did not know a word of Italian. The director therefore made it obligatory for the Italians to learn Croatian, and for the Croatians to learn Italian.

Ing. Jamnicki, replying to the discussion, said that the laboratory at the yard was under the authority of the production manager. It did not undertake research to the extent that was done in the laboratories at Ljubljana, but was concerned mainly with testing materials.

It had been suggested that the functions of the secretary might be combined with those of the financial director, so that one man could perform the duties of both. That might be done, but the secretary had many different kinds of work to do; for instance, his responsibilities included safety, and the fire department.

With regard to training and schools: in the past there had been an apprentices' school at the yard, but about two years ago a school for all industries was organised at Pula. It was felt, however, that they should have their own school at their own yard, though the central school was well attended. The item "liquidation" referred to the liquidation of orders.

The workers' council met about once a month, always after working hours, and were not paid for that service. The members of the executive committee discussed all important fundamental questions and problems arising in the yard, and approved all changes of personnel, etc. They did not have regular meetings and did not meet often; perhaps once a week.

With regard to the comments on the sales division, the paper stated that the organisation depended on the personnel available; it also depended on the size of ship to be built. It would be possible, perhaps, to have the division under the authority of the commercial director; but there must be close co-operation with the technical divisions, and care must be taken to ensure that reasonable costs for the work to be done were not exceeded. Technical inspection was under the technical director and the production manager; shortly after the paper was written, there was a change in that part of the organisation.

The Chairman, in proposing a vote of thanks to the author and to Mr. Jamnicki, said that the organisation described in the paper might appear to be complicated, but the establishment was not only a shipbuilding yard; it was also a repairing works and an engine works. Comparison with a corresponding British yard would show that it had practically the same organisation, but with different names for the various people. He had always been a believer in having a works committee, practically on the lines of that at the Uljanik yard, particularly in new shipyards; it was of the greatest possible help to have a committee elected by the workmen, to consider all sorts of things, except wages. They would consider the organisation of the shops, and similar matters, in order to suggest means of making things easier for everybody. Any workman who had any sort of suggestion to make brought it to the committee, and they put it up to the manager.

He was also a great believer in training schools. A boy who was taken on as an apprentice came straight from school; before taking him from a more or less sheltered life into the hurly-burly of the works, it was only right that he should go into the school, where he would have explained to him the various tools he would have to use, and how to use them. He received training for one or two years before he passed to the workshops, and the time he spent in the school could not be regarded as a complete loss to his employers, for a certain amount of the work he did during training could be productive.

It was possible to suggest a few changes in the organisation described in the paper. The financial director should be responsible for the secretary and the legal people, and for commercial matters. The technical director should be responsible for the production of ships. The technical director was in effect the general manager, and the production manager was the works manager.

To be continued

The Iron and Steel Institute (*continued from page* 559)

DEVELOPMENTS AT SCUNTHORPE IRON AND STEEL WORKS

USE OF SINTERING PLANT AND BOSH TUYERES

At the conclusion of the speeches of welcome on the first morning of the special meeting of the Iron and Steel Institute, held in Scunthorpe, Lincolnshire, from Wednesday, October 12, to Friday, October 14, two technical papers were presented. Both dealt with recent developments at iron and steel works in Scunthorpe.

IRONMAKING AT APPLEBY-FRODINGHAM

The first paper, on the subject of "Developments in Ironmaking at Appleby-Frodingham," was by Mr. G. D. Elliot, works manager (iron) at the Appleby-Frodingham Steel Company. He stated that the last decade had seen serious deterioration in coking coals and in the local iron ores. The sulphur content in the coking coal had increased as it had also in the iron ore. The iron content of the ores had decreased and the amount of ferrous iron had increased. All these factors had added to the difficulties of making pig iron economically from these materials, and ironmaking was now firmly established on the basis of carrying burden preparation to its logical limit and charging to the blast furnace high-quality coke and virtually nothing but sinter. The increase of sinter in the furnace burden to nearly 100 per cent. had led to very considerable savings in the cost of the iron. During recent years, moreover, intensive efforts had been made, and were continuing to be made, by the coke-maker to give the ironmaker a satisfactory fuel.

Since 1944 much new plant had been built, namely six sinter machines (two in 1951 and four in 1954); a complete ore-crushing and screening plant (1954); four additional ore driers (1951); two beds (on which ores are blended and mixed) and a second reclaiming machine added to the bedding plant (1951); two blast furnaces, together with gas-cleaning plant and other auxiliaries (1954); and four turbo-blowers with boiler (1954).

Four blast-furnaces were now in service, and their names and hearth diameters were as follows: Queen Mary (25 ft.), Queen Bess (25 ft.), Queen Anne (27 ft.) and Queen Victoria (28 ft. 6 in.). The plant additions which had come into operation in 1954 had been designed to provide a wholly-sintered burden for the production of approximately 1¼ million tons of pig iron a year. All the furnaces now used carbon-lined boshes with spray-cooled welded-steel jackets. By the end of 1952 every blast furnace at Appleby-Frodingham had been equipped with and was using bosh tuyeres. The furnaces built in 1954 (Queen Anne and Queen Victoria) had been designed with bosh tuyeres, which had been in constant use since blowing-in. The use of bosh tuyeres and the practice of frequent checking had led to an increase in furnace production. In 1944 the first carbon hearth had been built into the Queen Bess furnace and as each furnace had become due for re-lining, carbon hearths had been installed. At present, carbon was accepted as the standard refractory for both hearth and bosh construction.

For many years ironmaking results in winter had been poorer than in summer. The position, however, had completely altered when using sinter burdens. Obviously, the physical quality of sinter was not affected by atmospheric conditions. This was a very important and valuable factor in the use of sinter burdens. Operation was now maintained at a much more uniform level throughout the year and spells of severe weather no longer had repercussions on ironmaking and consequently on steelmaking. The smelting of sinter gave rise to problems which were quite different from those that arose when smelting ores.

DISCUSSION: DRIVING BLAST FURNACES HARD

Mr. James Mitchell, C.B.E., who opened the discussion, stated that the data on heat balances, given at the end of the paper, were misleading, because the total B.T.U.'s shown there were not the total needed to produce a ton of pig iron; they were merely what was needed to produce a ton of pig iron from Appleby-Frodingham sinter, which was an entirely different matter. It would be helpful if the total B.T.U.'s absorbed by the drying plant and the sinter plant, per ton of iron, were given.

Mr. R. P. Towndrow said that he had always thought that a uniform stack descent was one of the ideals in blast-furnace operation, but Mr. Elliot had now stated that this did not matter. He (Mr. Elliot) had once stated that bosh tuyeres were an iniquitous anachronism, yet he had now adopted them. From what Mr. Elliot had concluded it might be assumed, therefore, that what might be right for Appleby-Frodingham was not necessarily right for Glasgow or South Wales.

Dr. J. H. Chesters asked Mr. Elliot whether he thought that a 30 ft. hearth diameter was really the extreme size for a blast furnace. Was there any reason for believing that if the furnace were increased from 30 to 32 ft. there would not be an improvement? Secondly, during the last ten years production had moved up in a striking manner. There was one thing, however, that made him nervous about it all. If a machine were driven hard a good deal of extra strain was put on it. A blast furnace intended—not 20 years ago, but two or three years ago—to make some 7,000 tons of iron a week was being driven so hard that its output had risen to 11,200 tons in a week. Did not Mr. Elliot think that even his carbon hearth might let him down with such a production? Was there any clue to give a warning of a possible breakdown; did the iron or slag temperature tend to go up when the furnace was driven at these fast rates?

Mr. Elliot, in a preliminary reply, said that by smelting sinter they had taken from the furnace a considerable proportion of its metallurgical load and were able to do things which they had never been able to do previously. They were able to blow hard without making much flue dust, and to cut coke consumption and make more iron—and, incidentally, to make a little money out of pig iron.

The solution of one problem, however, was the formulation of another. They were now engaged in taking all the sinter from four machines and screening it at the last moment before feeding it to a blast furnace. The Queen Victoria furnace was being fed entirely with sinter of plus ⅜ in. size and all the minus ⅜ in. fraction was going to the other furnaces. Whether this would become permanent practice it was too early to say.

Dr. Chesters was worried about the possibility of the furnace wearing out. It was his responsibility to find the refractories that would stand up to the treatment. If, however, the furnace failed, it would be rebuilt but the hard-driving technique would be continued.

Major W. R. Brown, D.S.O., stated that at a conference held in 1952 Sir Charles Goodeve had asked the blast-furnace community to produce 10 per cent. more iron—in fact, he had challenged it to do so. He had said that 800,000 tons had been imported and he considered that it should have been made at home. Among the contributions to the discussion was one by Mr. G. D. Elliot, who had given particulars of outputs and had offered some promise with regard to other things that were still to come. He had fulfilled that promise magnificently. People who had said, "Can't" might now start to believe that even the impossible could be achieved, if the right methods were adopted.

Mr. Elliot, in a final reply, said that they did not claim to be selling a universal panacea, but the things which had been done had gone a long way towards solving the major problems of ironmaking at Appleby-Frodingham. Every step taken had reduced the total carbon consumption, even including the ignition gas and coke breeze in the sintering. The volume of slag to-day was considerably higher than it was 50 years ago. It varied little from 25 or 26 cwt. of slag per ton of iron. Queen Victoria had averaged 9,600 tons of iron a week for four weeks, and that meant it had turned out something like 12,000 or 13,000 tons of slag. From that one furnace the total liquid output had been well over 22,000 tons per week. It was much more difficult to dispose of slag than to dispose of iron.

There was nothing wrong with a furnace of over 30 ft. diameter, and designs for relining Queen Victoria to 30 ft. 6 in. or 31 ft. were on the board. The crossing of the 30 ft. line was much more of a mental hurdle than a physical one. The crossing of the 20 ft. line had met with the same kind of doubt that was being voiced to-day. It was felt that other people ought to experiment with bosh tuyeres because they provided one of the few fittings on a blast furnace which did not involve a heavy outlay. If they were not a success they could easily be discarded. They believed that for practice at Appleby-Frodingham bosh tuyeres were correct.

EXPANSION OF LYSAGHT'S SCUNTHORPE WORKS

The second paper presented dealt in broad outline with "The Expansion Scheme of John Lysaght's Scunthorpe Works, Limited," and was by Mr. W. L. James, J.P., managing director of the firm. He stated that the company's steel works at Normanby Park had been opened in 1912, and that a modernisation and expansion scheme, involving an expenditure of £10½ million, had been carried out in all departments to increase the weekly output of pig iron from 4,659 tons in 1948 to a new weekly average of 7,200 tons, of steel ingots from 6,062 tons to 10,500 tons, and of rolled steel from 4,998 tons to 10,500 tons. To bring about these results had meant, in effect, the complete replacement of the rolling mills and a large remodelling and rebuilding scheme in every department of the works. The scheme had included the construction of two batteries of coke ovens, each of 23 Woodall-Duckham ovens; the building of a new blast furnace having a hearth diameter of 22 ft. 6 in., and the re-building of another one; the erection of a new 120 ton fixed open-hearth furnace and the enlargement of three others to a similar capacity; the building of new cogging and billet rolling mills, and the transfer of a rod rolling mill, previously working at the Castle Works of Guest, Keen and Nettlefolds, Limited, at Cardiff, to the Normanby Park Works.

The whole scheme had been of the order of a "green-field" conception, but unfortunately no green-field site had been available. Hence the project had had to be carried out so far as was possible without interfering with maximum production. By December, 1950, the weekly average of ingots rolled had risen to 7,430 tons. A year later 10,000 tons had been exceeded for the first time, and the weekly average for November, 1952, had been in excess of the target figure of 10,500 tons, just over two years after the first bar had been rolled.

DISCUSSION: WORKING MODELS AS TRAINING AIDS

Mr. Richard Mather, who opened the discussion, said that Mr. James's paper had shown how a very difficult problem had been solved success-

fully. It was a problem which arose from time to time, when it was desired to bring up-to-date works which had been adequate when they were built, but which had not kept pace with current requirements.

The paper would be a valuable source of reference to works engineers for a long time to come, not so much because the same solution could be adopted in other works, but because of the confidence it would give to other engineers in showing them that what seemed almost an impossible problem of adapting an old works into a new one could be solved.

One of Mr. James's greatest helps had been the collection of working models he had made. These had been employed to show men who were unaccustomed to work entirely new plant, the best method of using this. Naturally, when the time for the conversion had come, there had not been much time for preliminary training, on account of the ever-pressing demand for output; there was little doubt that the models had been a considerable factor in helping the men to reach the maximum output from the new plant as quickly as they had done.

Sir Charles Goodeve asked Mr. James regarding the price of land around Normanby Park? It seemed to be a most valuable area. The original works had been compressed into a tight, compact area. How much more land had been taken up by the new plant and was there any more space available for future development?

Mr. James, in reply, said that the works were now very circumscribed, and it would be impossible to extend on that site, but there was room on the opposite side of the road to build another works, and there was a railway connection. The cost of erecting this, however, would be very great indeed. While large outputs were very necessary, they must be economic and the price must be competitive.

To be continued

AUTOMATIC CONTROL IN THE PROCESS INDUSTRY

COLLABORATION BETWEEN PROCESS AND INSTRUMENT ENGINEERS

The decision to hold a joint conference of the Institution of Chemical Engineers and the Society of Instrument Technology to discuss automatic control was taken at an appropriate time, and resulted in an attendance at Church House, London, S.W.1, on October 4 of over 750 people, nearly double the number originally anticipated by the organisers. Apart from the inevitable difficulties involved in catering for such large numbers, the conference proceeded without delays, and Mr. J. F. Coales and Dr. N. E. Rambush, the chairmen in the morning and afternoon sessions respectively, were able to complete their large programmes and still allow sufficient time for valuable discussion.

The conference was introduced by the President of the Institution of Chemical Engineers, Mr. J. A. Oriel, C.B.E., who emphasised the need for the extension of the use of automatic control methods to the smaller industries. In many cases he considered that the trade unions were even more responsible than the management for the tardy introduction of automatic control, and continued to say, " their fear of unemployment as a result of using automatic equipment amounts almost to an industrial disease. If, as is right and proper, their duty is to increase the pay-packet of their members, then they should use every possible means to compel management to install equipment which will improve quality and increase production. I make no apology for introducing this somewhat contentious note; we scientists and technologists too often expose ourselves to criticism because we turn a blind eye to the social effects of our discoveries and developments."

The morning session was devoted to the discussion of the systems used for the control of chemical processes, and Mr. R. S. Medlock (George Kent, Limited) provided a lucid demonstration of the effects of various control systems on a " closed loop " system. His paper, entitled " The Fundamentals of Automatic Control," was followed by " The Dynamics of Process Plant," read by Mr. J. McMillan (I.C.I.), who gave an introduction to the frequency response analysis of dynamic systems, a technique which will enable valuable information for the design of future control systems to be obtained. Mr. B. W. Balls and Mr. A. H. Isaac (Foxboro-Yoxall, Limited) concluded the morning session with a paper in which it was shown that designers should consider instrumentation in the initial stages of design and not, as is often the case, after the process details have been decided.

In the subsequent discussion, instrument manufacturers were accused of losing sight of the fact that many industries do not require the modern highly developed systems, and could be considerably improved by the introduction of only the simplest of controls. In his reply, Mr. Balls pointed out that what may appear to be a simple plant to control in fact often required considerable alteration in capital equipment, which many managements refused to undertake. It was also agreed that there was a general shortage of reliable instruments for the continuous measurement of physical and chemical properties of the products, which represented a serious problem in many industries.

The afternoon session commenced with four short papers on the application of automatic control systems in various industries. The authors covered a wide field varying from the exact control of the thickness of steel sheets leaving a rolling mill at the rate of 2,000 ft. per minute, to the batch production of synthetic resins. Mr. S. W. J. Wallis (British Petroleum Company, Limited) presented a paper on " The Economics of Process Control," in which the installation and operating costs of the instrumentation for a medium sized refinery unit were analysed. Mr. A. J. Young, President of the Society of Instrument Technology, gave the final paper and attempted to predict the future requirements that industry will expect from chemical and instrument engineers. He emphasised that progress depends greatly on the closeness and collaboration between maker, user and the research establishment. Product quality would probably be the basis of control in future systems, and integrated multi-loop systems would be employed. Feed-forward control would also be needed, by which adjustments would be made ahead of disturbances before they had influenced the process. Another item would be the self-optimising controller which would automatically set the best conditions. Mr. Young also stressed the point that the control engineer should be called in early in the design of the plant.

The conference was concluded by an address from Sir Harold Hartley which was read in his absence by Mr. Young. Independently, he expressed a desire which had recurred during the day, for an information centre for the assimulation and dissemination of the available data on instrumentation, and he hoped that the proposed formation of a National Chemical Engineering Laboratory might provide this service together with the facilities for fundamental research.

It was notable during the conference that the word " automation " was only used twice and on both occasions with a plea that it should be abandoned because it was a harmful and misleading description of an invaluable aid to industry.

EXTENDED TELEVISION COVERAGE

New Stations for B.B.C. and I.T.A.: Experiments with Colour

The most striking characteristic of the constructional work being done for the Independent Television Authority is the speed at which the new installations are built. This applied to the London transmitting station and the Wembley studios of Associated Rediffusion, and also applies to the stations at Lichfield and Rivington Moor, near Bolton, which are now being constructed.

At Lichfield the transmitting equipment is made by Pye Limited, Cambridge, and the tower and aerial array by Marconi's Wireless Telegraph Company Limited, Chelmsford, Essex. The vision transmitter is designed to give a peak white power output of 20 kW and operates with an associated 5 kW sound transmitter. In the near future a similar set of transmitters will be installed which are intended to be operated in parallel with the first set to provide a service with complete standby facilities. The aerial tower is 450 ft. high and the aerial array is a 16-stack high-gain aerial. Ultimately it is intended to be used as a split 8-stack array, each half being fed by one vision and one sound transmitter.

Other television developments are the station for the I.T.A. at Rivington Moor and that for the B.B.C. at Core Hill, Meldrum, Aberdeenshire. The station and aerial at Rivington Moor are being constucted by Marconi's. They were also responsible for the main transmitters and aerial system at Meldrum, which was opened on October 12. The 5 kW vision transmitter there is designed to handle colour transmissions as well as black and white. When Meldrum is in commission, with its 500 ft. aerial mast and effective radiated power of 12 kW., the service area is expected to extend eastwards of a line running from Moray along the foothills of the Grampians to Montrose.

The B.B.C. have started experiments on the broadcasting of colour television transmissions, but it is likely to be some time—possibly three years—before there are colour programmes broadcast or many sets to receive them. The main purposes of the present tests are to see whether the reception of colour is satisfactory, and whether the monochrome signal of the colour programmes received on normal sets is up to the standard of the present normal transmissions. The problem of compatibility (satisfactory monochrome reception of colour programmes on normal sets) is most important, because the cost of colour receivers is likely to be high and few people will be able to afford them. A representative price of a colour T.V. set in the United States is 800 dols., more than twice the average price of a normal set.

In the system used in the tests, which were demonstrated on October 20 at Alexandra Palace, two signals are transmitted simultaneously: one is the luminence signal which contains the picture brightness information, and the other the chrominance signal which contains the colour information. Both signals are contained within the 3 Mc band used for present-day black and white transmission.

Introducing the demonstration, Sir Harold Bishop, director of technical services, B.B.C., said that the B.B.C. were going to make a series of experiments on colour transmission and reception. They were at present tied to no standard transmission characteristics—number of lines and frames per second—nor was it certain that the system adopted would be compatible. The results of the tests would be submitted to the Television Advisory Committee, who would in turn report to the Postmaster General. When a system had been definitely adopted, suitable colour receivers could be designed.

THE COLLAPSE BEHAVIOUR OF VIERENDEEL TRUSSES*

By S. Henderson, B.SC., PH.D.

The Vierendeel truss exhibits a plastic collapse behaviour typical of all rigid-jointed frameworks, that is, it collapses by the formation of sufficient plastic hinges to form a mechanism with one degree of freedom. This paper describes the collapse behaviour of several model Vierendeel trusses, tested by the writer, and compares their behaviour with the simple plastic theory. However, the beginning of the paper is devoted to an introduction to the simple plastic theory.

THE SIMPLE PLASTIC THEORY

Reference was made above to "a plastic hinge." This is a term used to describe the characteristic behaviour of a mild-steel section, in bending, once it has yielded throughout its entire depth. The concept of a plastic hinge will be more readily understood by considering the diagrams of Fig. 1. Fig. 1(*a*) represents a simplified version of the stress/strain behaviour of mild steel in tension or compression. Assuming that, in bending, beam fibres exhibit a stress/strain behaviour exactly in accordance with Fig. 1(*a*) (despite the fact that they are not free to expand and contract laterally) then the stress distributions in the beam will be similar to those in Fig. 1(*b*) as the beam is loaded from the elastic range into the plastic range. When the final stage (II) of Fig. 1(*b*) is reached, all of the beam fibres support their limiting stress—the yield stress f_y—and the beam has reached its limiting moment of resistance. Fig. 1(*c*) shows a typical curve of moment/curvature of a mild-steel beam, bent to collapse. When the fully plastic state (II) is reached, the curvature increases indefinitely with no further increase in moment of resistance. In this aspect the fully yielded section acts as a hinge. The limiting moment of resistance is termed M_p, and its value, for any section, can be calculated from a knowledge of the yield stress and the first moment of area of the section.

Collapse Mechanisms.—When a rigid-jointed structure has developed sufficient plastic hinges to give it one degree of freedom, it will collapse. Thus an encastré beam will collapse upon the formation of three plastic hinges in its length, while a fixed-foot portal, with wind loading, requires four hinges. Collapse of a rigid-frame structure is thus identified by the completion of a collapse mechanism. The plastic design method bases its working load on the collapse load, i.e., the real limiting carrying capacity, of a rigid-jointed structure. The important difference between this concept of a structure's strength, and that of the conventional elastic design procedure, is immediately obvious. The elastic method, by accepting as its failing load that load necessary to cause first yield in the structure, only takes into account the strength of single members, namely, those in which the highest stress intensity occurs. The extra strength a rigid structure possesses, a strength inherent in its continuity of member connection, is thus neglected. Consequently, while the elastic method provides an appropriate criterion of safety for statically-determinate structures, it can be unduly conservative as an estimate of the strength of a statically-indeterminate rigid-frame structure. The plastic method of design is the only logical approach to this type of design problem.

* Paper prepared for reading before Section G of the British Association at Bristol on Tuesday, September 6, 1955.

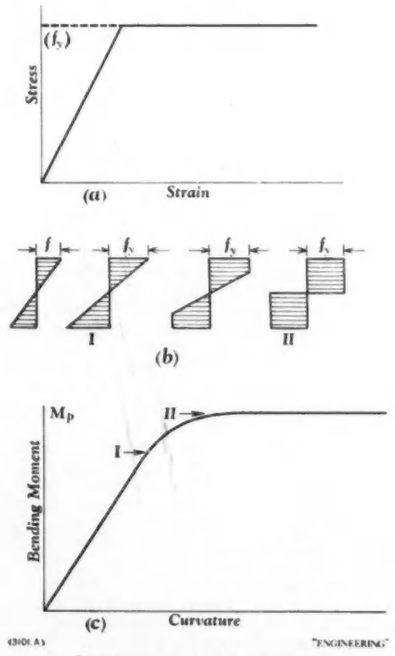


Fig. 1 Stress-strain behaviour of mild steel beams.

PLASTIC METHOD OF DESIGN

Collapse occurs by the formation of a hinged mechanism, and the plastic method of design consists of postulating the various collapse mechanisms a structure can assume, and calculating the respective collapse loads. Then the correct collapse mechanism will be that for which the collapse load is a minimum, provided that the following conditions are also satisfied: (*a*) the internal force system is in equilibrium with the external force system; and (*b*) the limiting moment M_p, is nowhere exceeded in the structure.

The method of calculating the collapse load appropriate to any mechanism is generally accomplished by a virtual-work process. This equates the external work done by the collapse loads, moving through plastic deflections, to the plastic work of rotation done in the hinges against the moments M_p. Elastic deformations are regarded as being negligible, compared to plastic deformations. While this method is admirably suited to the plastic analysis of a Vierendeel truss, it is not always necessary to employ it. In fact, the plastic analysis of a Vierendeel truss is usually a statically-determinate problem. Such an example is worked out below. However, the next section deals with the effect of axial and shear stresses that are encountered in the plastic range.

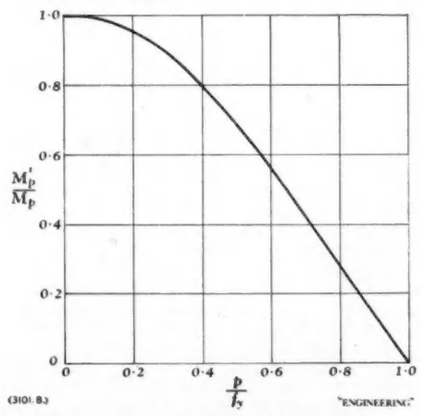


Fig. 2 Curve of reduction in the plastic bending moment due to axial stress.

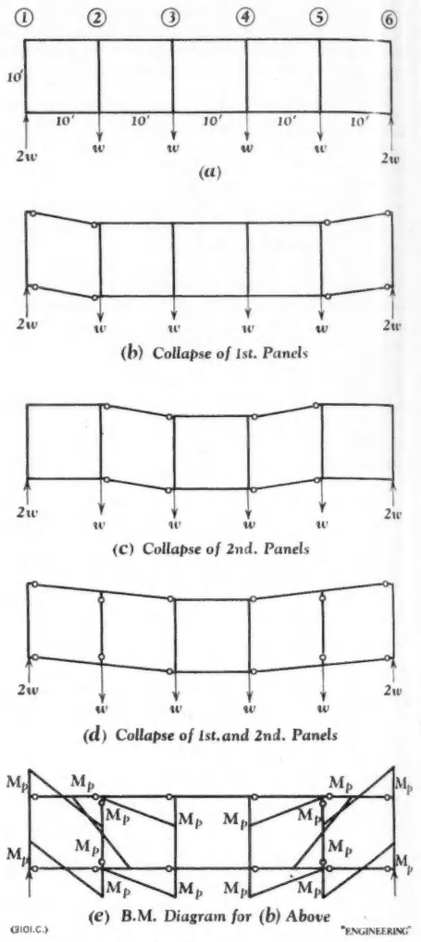


Fig. 3 Possible collapse mechanisms for a five-panel truss. The design of such a truss is fully considered in the article.

AXIAL AND SHEAR STRESSES

The previous section has dealt only with bending stresses, since these are the predominant stresses in a rigid structure. Furthermore, the collapse mechanism represents failure by excessive bending. However, it is still necessary to account for the effect of the axial and shear stresses in a structure, especially when these reach the same order as the bending stresses. Axial stress reduces the M_p value a section will support. The amount of this reduction can be readily calculated, provided the distribution of axial stress is uniform across the beam section. The result of calculating the reduced M_p for various values of axial stress is a "reduction curve" of the type shown in Fig. 2[4]. Thus for any value of axial stress, the appropriate M'_p value can be read off the reduction curve and used instead of M_p in the plastic analysis. In the graph, M_p = fully plastic moment; M'_p = reduced plastic moment; p = axial stress; and f_y = lower yield stress.

Shear stresses have been shown, by calculation and experiment, to have a negligible effect upon the carrying capacity (M_p value) of a simply-supported beam, until the beam is so short that it will fail by shear alone. Consequently, the

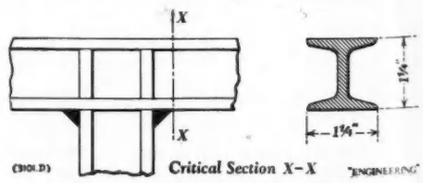


Fig. 4 Joint detail used for models.

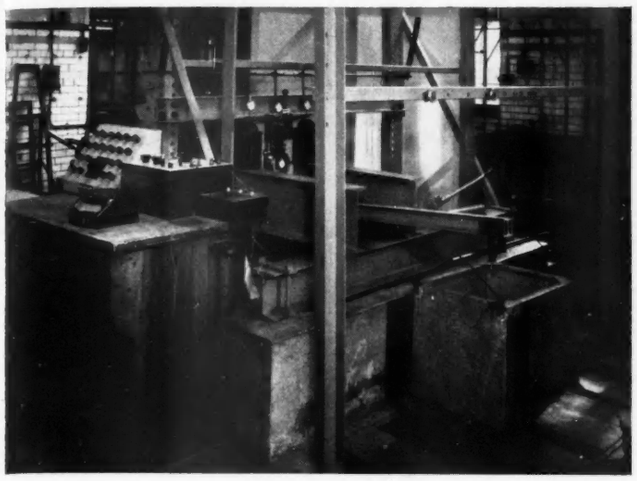


Fig. 5 General view of test rig with a simply-supported beam under test. The load, which is measured on the proving ring, is obtained by running water into the tank and keeping the lever arm horizontal with the aid of the hydraulic jack (partly hidden by the proving ring).

present tendency is to ignore shear stress as a factor affecting collapse loads of structures. Recent research[5] has, however, indicated that the shear stress in certain welded-joint designs requires consideration if the joint is expected to remain rigid up to the development of M_p in the member adjacent to it. This is, however, a refinement of the simple theory and will not be considered in the general analysis.

ANALYSIS OF A VIERENDEEL TRUSS

The truss to be designed is shown in Fig. 3 (*a*) and its various possible collapse mechanisms in Figs. 3 (*b*), (*c*) and (*d*). The truss will be considered to have a constant section throughout, for the sake of simplicity. The first step is to determine the correct mechanism by which the structure will collapse. By inspection, it is evident that mechanism (*c*) (collapse of second panels) cannot be valid, since the vertical shear force is highest across the first panel, and collapse of the first panel must, therefore, occur before collapse of the second. Thus, it only remains to differentiate between mechanisms (*b*) and (*d*).

Considering mechanism (*b*) and the shear equilibrium of the first panel

$$2\,W = \frac{4\,M_p}{10}.$$

Therefore

$$W = 0{\cdot}2\,M_p. \quad . \quad . \quad (1)$$

For mechanism (*d*), take moments about the third vertical member. Then $2\,W \times 20 - W \times 10 = 2\,M_p + 10\,U_2$. Therefore $30\,W = 2\,M_p + 10\,U_2$, where U_2 = the axial force in the chords of the second panel. But U_2 is equal to the sum of the shears in the vertical members, i.e.,

$$U_2 = \frac{4\,M_p}{10}.$$

Therefore

$$30\,W = 6\,M_p \quad \text{or} \quad W = 0{\cdot}2\,M_p. \quad (2)$$

Thus both mechanism (*b*) and (*d*) require the same collapse load. To differentiate between them it is necessary to check all of their external equilibrium equations. This is most easily accomplished by establishing their bending-moment diagrams. Considering mechanism (*b*), since moment M_{21} is the same sign as M_{23} (i.e., anti-clockwise), then M_{23} must be zero, otherwise the moment M_3, at the top of vertical 2, would have to exceed M_p to balance them. This establishes the moments M_{32} as equal to M_p and the B.M. diagram is reproduced in Fig. 3 (*e*). It is now evident that the disposition of plastic hinges is the same as that for mechanism (*d*) and, in fact, this collapse of both panels represents the manner in which the truss will fail.

It now remains to refine the calculation for finite member width and axial stress. In practice, the first calculation would be used to apportion preliminary member sizes for the final calculation. However, for the convenience of this example, the member depth will be accepted as one-tenth of the panel length, i.e., 1 ft.

Considering the shear across the second panel,

$$W = \frac{2\,M'_{p2}}{(10 - 0{\cdot}5)} = \frac{2\,M'_{p2}}{9{\cdot}5} \quad . \quad (3)$$

M'_{p2} = the reduced M_p value for the second panel.

The axial force in the chords of the second panel is equal to the sum of the vertical member shears, i.e., equals.

$$\frac{2\,M'_{p1}}{(10-1)} + \frac{2\,M_p}{(10-1)}$$

(M'_{p1} = reduced M_p value for the first panel).

$$= \tfrac{2}{9}\,(M'_{p1} + M_p).$$

The axial force in the first panel $= \frac{2}{9}\,M'_{p1}$, i.e. $U_1 = \frac{2}{9}\,M'_{p1}$ and $U_1 = p_1\,A$, therefore

$$M'_{p1} = \tfrac{9}{2}\,p_1\,A \quad . \quad . \quad . \quad . \quad (4)$$

where p_1 = axial stress in first panel, and A = area of member.

Equation (4) will plot as a straight line on the same axis as the reduction curve of Fig. 2. Its intersection with the curve will give the value of M'_{p1}. From this, the value of the axial force in the second panel can be calculated and hence M'_{p2}. The collapse load is, of course, given by equation (3).

Description of Model Trusses.—The model trusses were fabricated from 1¼ in. by 1¼ in. I-section, the joints being formed by electro-welding. A simple and frequently used joint detail was adopted (see Fig. 4) and adhered to during the whole of the investigation. Since it was considered impracticable to study the behaviour of more than one type of rigid connection, joints with inside fillets, typical of most Vierendeel bridges, were not employed. The plastic hinge at a joint such as that in Fig. 4, was considered to be at the section X-X, for the purposes of calculation. This section (of max. $\frac{M}{Z}$ value) is henceforth referred to as "the critical section." All trusses tested were loaded at a single panel point in the lower chord only. In most cases a lug was welded to the underside flange (see Fig. 7) to accommodate the roller of the loading shackle. In a few other instances, the loading shackle roller passed through a hole drilled in the web of the vertical member at this panel point (Fig. 14).

Initial Condition of Trusses.—Owing to a lack of heat-treating facilities at the beginning of the investigation, it was not possible to stress-relieve all of the trusses. The stresses due to welding should have been negligible in such thin material

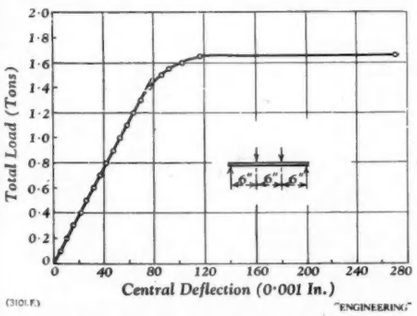


Fig. 6 Load/deflection curve for 1¼ in. by 1¼ in. I-section.

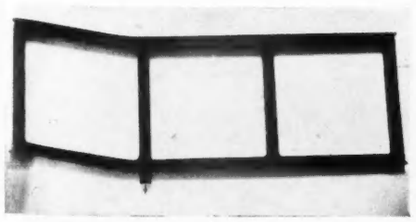


Fig. 7 Collapsed three-panel truss 3PU.

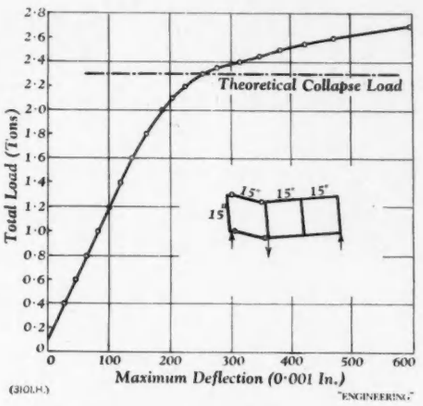


Fig. 8 Load/deflection curve for truss 3PU.

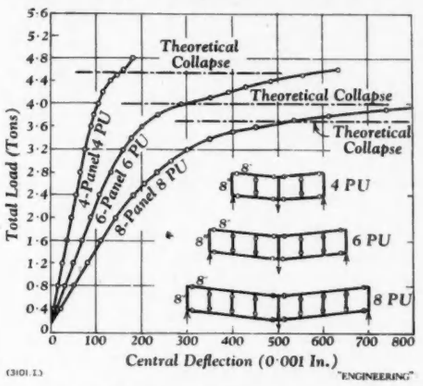


Fig. 9a Load/deflection curves for trusses 4PU, 6PU and 8PU.

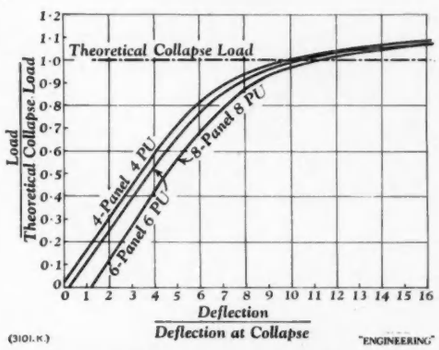


Fig. 9b Ratio of load to theoretical collapse load plotted against ratio of deflection to deflection at collapse, for trusses 4PU, 6PU and 8PU.

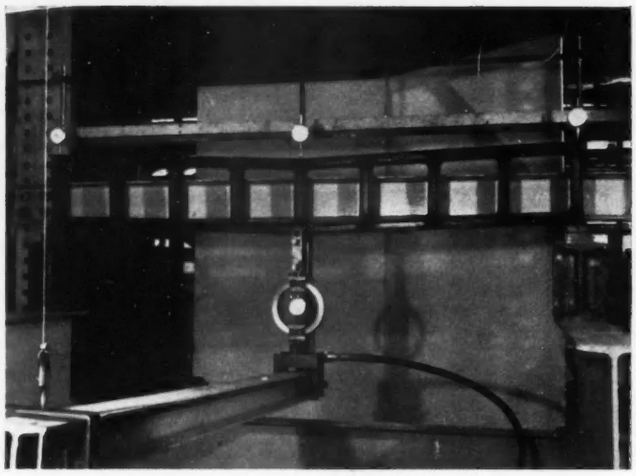


Fig. 10 Collapsed eight-panel truss 8PU.

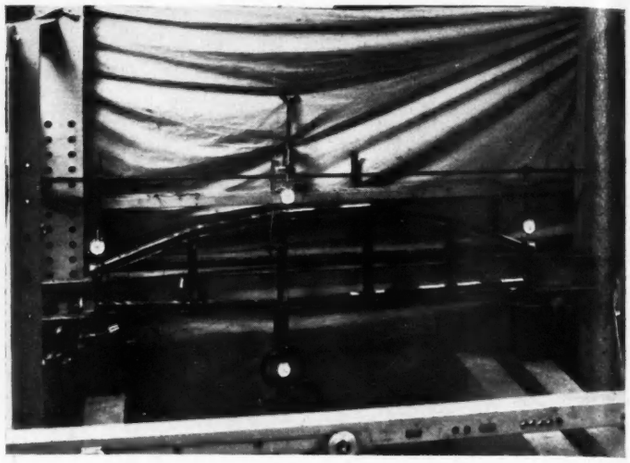


Fig. 13 Collapsed five-panel truss 5PU.

(¼ in. thick) but it was found that, in several tests, the as-welded trusses were initially stressed due to an initial lack-of-fit (of members) being pulled together by welding. This initial stressing took the form of a self-balancing bending-moment distribution throughout the truss. The test results show that the collapse loads were not affected by this bending-moment system, but the deflections in the plastic range were sometimes appreciably affected. Those trusses which were stress-relieved were mostly treated at 600 deg. C for 45 min., but as a check on the efficiency of this stress relief, other identical trusses were fully annealed at 920 deg. C. The close comparison in results showed that the first treatment was adequate.

DESCRIPTION OF TEST RIG

The models were tested in a lever-type testing rig, of 5 tons capacity, constructed in the workshops of the Civil Engineering Department. Fig. 5 shows a general view of this apparatus, with a simply-supported test beam in position. The load applied to the trusses was maintained truly vertical by providing a nest of rollers, allowing freedom of horizontal movement at the fulcrum.

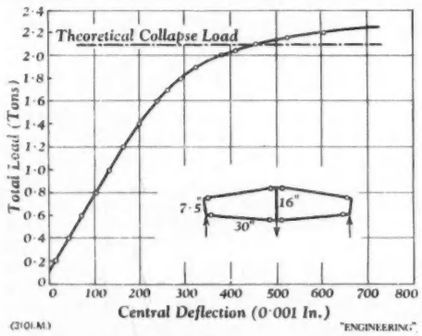


Fig. 11 Load/deflection curve, truss 2PU.

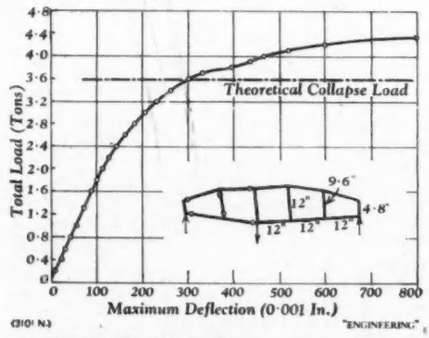


Fig. 12 Load/deflection curve, truss 5PU.

Between these rollers and the beam supplying the fulcrum reaction a hydraulic jack was located. The function of this jack was to maintain the lever approximately horizontal during plastic deflections. The live load was provided by water, the 17 gallon tank being visible in Fig. 5, and the load applied to the trusses was measured by means of the proving ring also shown in this illustration. To prevent failure by lateral instability, and also to maintain the models in the loading plane, thin bracing cables were clamped to the members of the trusses and guyed to the testing-rig frame through tensioning bolts at their opposite ends.

Deflection readings were made by means of dial gauges, suspended from the bridge shown in Fig. 5, and strain measurements were made by means of both electrical and mechanical (Huggenberger) type gauges. The strain readings were made by diametrically-opposed gauges, located in those parts of the members which remained elastic throughout the whole load range of the structure. From their average values, converted to bending moments, it was possible to extrapolate the values at the critical sections, i.e., the assumed plastic-hinge sections. These values, of moments at critical sections, afford a comparison between the actual and theoretical limiting moments at the plastic-hinge sections. Lack of space prevents their inclusion and discussion for all of the trusses described in this paper, but it is hoped to make detailed reference to them in a later publication. A check on the measured critical-section moments was made by substituting their values into the external equilibrium equations. In general, an excellent agreement was obtained, the maximum error being about five per cent.

DISCUSSION OF TESTS

Control-Beam Tests.—The M_p value of the section, in pure bending, was determined by control-beam tests. Two-point loading at the one-third span points was employed, the average M_p value of the section being found to be 4·95 tons-in., corresponding to a lower yield stress of 17·8 tons per square inch. Fig. 6 shows a typical load/deflection curve for a beam in its as-received condition.

Three-panel Truss 3PU.—This truss was tested in the as-welded condition, its collapsed form being shown in Fig. 7. Fig. 8 shows its load/deflection diagram and theoretical collapse mechanism and load. A fairly good agreement can be seen to exist between actual and theoretical loads, although the onset of strain-hardening prevented a definite collapse load from being exhibited. The deflections in this, as in all other trusses, were measured relative to the supports.

Four, Six and Eight-Panel Trusses 4PU, 6PU *and* 8PU.—The load/deflection curves for these as-welded trusses have been plotted with actual values in Fig. 9(*a*), and replotted to dimensionless ordinates in Fig. 9(*b*) in order that their behaviour may be more easily compared. Theoretical and actual collapse loads were in good agreement, and, as can be seen from Fig. 9(*b*), the strain-hardening behaviour of the trusses was virtually identical. The collapsed eight-panel truss is shown in Fig. 10. The effect of axial stress was taken into account in the calculations, its value in the central chord of 8PU being as much as 9 tons per square inch.

Two-panel sloping-chord truss 2PU.—The load/deflection diagram is reproduced in Fig. 11, the theoretical collapse mechanism and truss dimensions being shown in the same figure. The truss was tested as-welded. A close agreement between actual and theoretical collapse loads was again exhibited. The sloping or curved upper-chord trusses involve a horizontal sidesway of the verticals in their collapse mechanism, which requires a greater rotation of the vertical member hinges than occurs for the same deflection in a parallel-chord truss. This latter

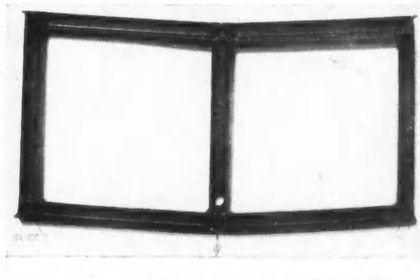


Fig. 14 Collapsed two-panel truss 2 PS.

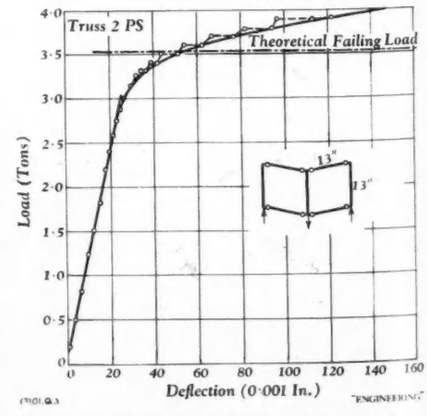


Fig. 15 Load/deflection curve. Two-panel truss 2PS.

behaviour is related to the greater axial force which occurs in curved or sloping chords.

Five-Panel Curved-Chord Truss 5PU.—Truss 5PU was tested as-welded, its load/deflection diagram being reproduced in Fig. 12. Its collapsed form is shown in Fig. 13. The actual collapse load was somewhat higher than the theoretical value and it is felt that this was the result of error in the calculation of collapse load, caused by the assumption that plastic hinges occurred at the critical sections (of maximum $\frac{M}{Z}$ value) such as X-X in Fig. 4. It is believed that the plastic hinges were probably located slightly farther away from the joint centre lines than is the critical section. This behaviour will be discussed in the next section.

Two-Panel Truss 2PS.—This truss was used in one of a series of tests undertaken immediately satisfactory heat-treating facilities became available. In the previous tests, on as-welded trusses, the measured hinge moments at collapse had rarely been equal to the M_p value of the section. However, the possible existence of residual welding stresses prevented any definite conclusions from being drawn for this difference. When the opportunity arose of testing initially stress-free trusses, it was considered a matter of first importance to check the agreement between the theoretical and actual values of their hinge moments. At the same time, it was decided to reduce the effect of axial stresses to a negligible amount by a suitable choice of truss proportions. The shear stresses could not be controlled so readily, however, since the truss dimensions were limited by the size of the heat-treating furnace. However, with the dimensions shown in Fig. 16, shear force in the members, at collapse, was limited to one half that necessary to cause yield in the section, when tested as a simple beam. This was considered to be small enough for the purposes of the test.

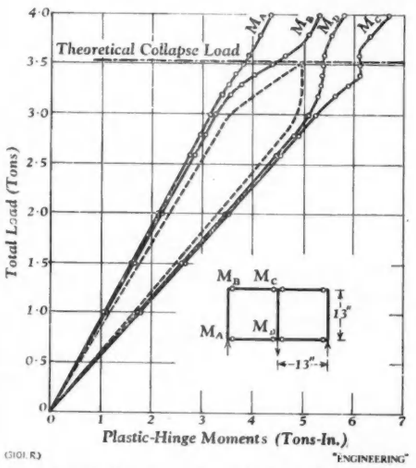


Fig. 16 Bending moments at the critical sections where plastic hinges are formed, truss 2PS.

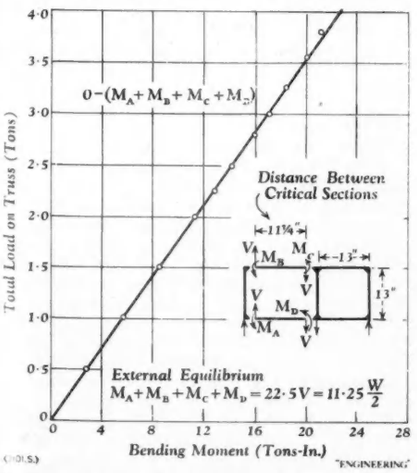


Fig. 17 External equilibrium check, truss 2PS.

For the sake of brevity only one of the trusses in the series will be discussed, but its behaviour is typical and the conclusions drawn will be general to the whole series. The truss 2PS was stress relieved at 600 deg. C. and was loaded through a hole drilled in the web of the central vertical member, as shown in Fig. 14. The purpose of this arrangement was that it maintained the central joints geometrically identical, whereas the lug used in the previous tests strengthened the bottom flange of the joint to which it was attached. The load/deflection diagram, reproduced in Fig. 15, indicates that the truss displayed no definite collapse load, but that a close comparison existed between theoretical and actual values. The broken lines in this diagram join deflection points measured just after the application of load and points measured when deflections had fallen to a negligible rate of increase.

Fig. 16 shows the diagram of moments at hinge critical sections, that is, the values of measured bending moment extrapolated to the sections such as X-X in Fig. 4. There is also drawn on Fig. 16 a theoretical construction (broken lines) representing the trend of moments M_A, M_B, M_C and M_D as predicted by the simple plastic theory (neglecting strain-hardening). These broken-line curves meet at theoretical collapse load, the moments there all being equal to M_p (4·95 tons-in.)

Comparison of these curves with the measured values indicates an appreciable difference, although the trend exhibited by M_B and M_D is similar to the theoretical construction. Reference to the comparison between measured moments and applied shear in the external-equilibrium equation, Fig. 17, indicates that experimental accuracy was virtually exact in this instance. Consequently, the observed difference must be a real deviation from simple theory.

Fortunately, the reason for moments M_A and M_B being less than M_p at collapse is readily determined by reference to the Luders line patterns, which were noted in the flanges at these joints (the flanges having been polished previous to testing). These patterns indicated that, at collapse, yield deformation was confined to the inside of the joint. Furthermore, yielding did not extend to the region of the critical section at M_B (the assumed plastic-hinge section) until the theoretical collapse load had been appreciably exceeded, and did not extend to this region at all at M_A. This observation confirms the measured moment behaviour at these two critical sections. Subsequent tests carried out by the author on similar L-shaped joints fabricated from larger section (3 in. by 3 in. I-section) have shown that the reason for this localisation of the yield zones to the inside of the joint is due to yield of the joint web under high shear stresses, despite the fact that the shear stresses in the member outside the joint were only equal to half the yield stress in shear $\left(\frac{f_y}{2}\right)$. This also confirms the findings of a research team at Lehigh.[5] The plastic hinge at the L-shaped joints was, therefore, a yield zone inside the joint proper, forming at a lower value of moment than M_p.

The Luders line patterns at the T-shaped joints were not so informative, except to verify that yielding did not occur inside the joint proper, at these positions. The moment curves of Fig. 16 for M_C and M_D show that higher moments than M_p were resisted by the critical sections at collapse. This suggests that the plastic hinges were not located at the critical sections, but at some section farther away from the joint. For an explanation of this, it is necessary to make a further reference to the tests on joint specimens of larger section mentioned above.

Fig. 18 illustrates a collapsed T-shaped joint, showing clearly that the zone of complete plasticity, throughout the section depth, was not located at the critical section, but at some distance from it. This behaviour appears more comprehensible when it is realised that plastic deformation must take place to either side of the plastic hinge section for rotation to occur. The material of the joint does not yield, and in consequence the plastic hinge in the member is constrained to form farther away from the critical section. The moment of resistance at the actual hinge section is equal to M_p. That at the critical section will be proportionately greater.

In conclusion, although the load/deflection curve and moment trends of this truss appeared to confirm a close agreement between theoretical and actual collapse load, the agreement was actually fortuitous. In order to calculate collapse load, the hinge sections had to be assumed to be coincident with the critical sections, and to develop a resistance of M_p at collapse. In actual fact, the plastic hinges at the L-shaped joints were confined to the inside of the joint and did not develop a moment of M_p before allowing plastic rotation. This weakness of the L-shaped joints was offset by the behaviour at the T-shaped joints, for the assumption that plastic hinges occurred at the critical sections of these joints underestimated the value of the limiting moment that could develop there before severe plastic rotation occurred. This error in the assumption of plastic-hinge location is probably the reason for the actual collapse load of truss 5PU being higher than the predicted value.

The only other point of interest, arising from the moment diagram of Fig. 16, is the difference between M_A and M_B and the difference between M_C and M_D at collapse. Since these pairs of joints were geometrically identical, they should, in theory, have developed equal collapse moments. However, both M_A and M_D were in close proximity to a point of stress concentration, M_A to the support knife edge and M_D to the loading roller. Furthermore, yielding at these joints was observed to occur at a lower load than yielding at M_B and M_C. It is, therefore, felt that the high concentrated stresses affected the form of the yield zones and, therefore, the limiting resistance at joints M_A and M_D. Joints M_B and M_C, which were not subjected to such disturbing factors, developed respectively higher limiting moments.

Curved-Chord Truss 6*PA*.—Fig. 19 shows the collapsed form of truss 6PA, the collapse mechanism being confined to the two central panels. The truss was annealed at 920 deg. C.,

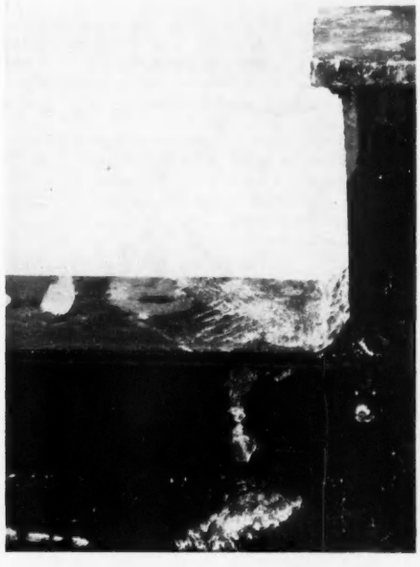


Fig. 18 Yield patterns in resin for a T-shaped joint specimen. The plastic hinge is located at approximately 2 in. from the critical section.

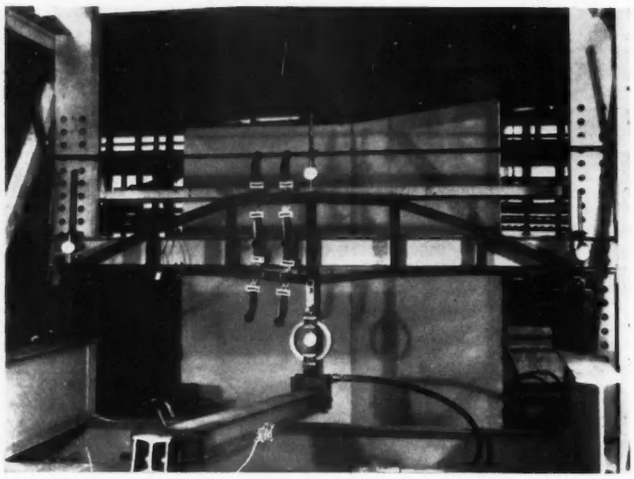


Fig. 19 Collapsed six-panel curved-chord truss 6PA. Failure is confined to the two central panels. This particular test was arranged to investigate the influence of high axial stresses in members.

the M_p value of the section in this condition being 3·20 tons-in. (from tests on simple beams). The reason for the test was to investigate collapse behaviour under very high axial stress. In this case the axial stress was about one-half of the yield stress (f_y) at collapse, and the M_p value of the section was expected to be reduced from 3·20 tons-in. to 2·12 tons-in., i.e., about 35 per cent. reduction. The load/deflection curve (Fig. 20) shows that the onset of strain-hardening again prevented the truss from exhibiting a definite collapse load. However, the load at which the first large deflection under constant load occurred is in approximate agreement with the theoretical collapse load.

The diagram of hinge moments (Fig. 21) confirms this agreement, the actual collapse load being identified as 2·60 tons (as compared to 2·54 tons theoretical). Above 2·60 tons, the moment curves display typical strain-hardening trends. On this diagram has been drawn the reduction curve of M'_p due to axial stress, the axial stress appropriate to any load being determined from strain measurements in that part of the member which remained elastic. It is immediately apparent that three of the hinge moments, M_B, M_C and M_D developed values almost coincident with the reduced M_p value at collapse. The fourth hinge moment M_A, fell considerably short, but this behaviour, it is felt, was due to weld yielding, since the tension weld at this joint eventually fractured at the maximum load sustained by the truss. The effect of this weld yielding, allowing large relative rotation of the joint members, would be to simulate the action of a plastic hinge at a lower value of applied moment than M'_p.

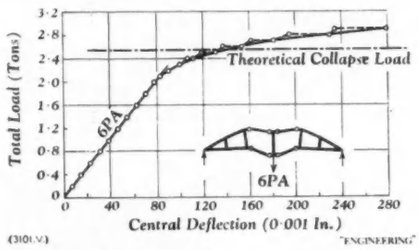


Fig. 20 Load/deflection curve of truss 6PA.

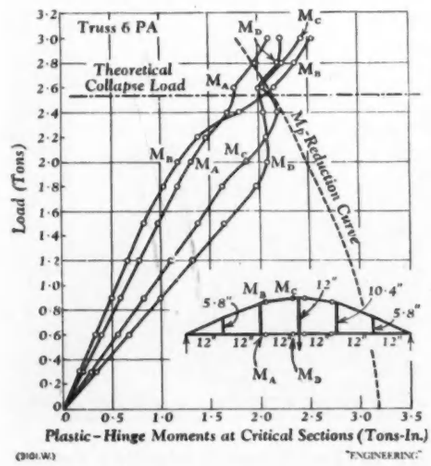


Fig. 21 Bending moments at the plastic-hinge critical sections, truss 6PA.

The near coincidence of the measured moments with the theoretical reduction curve, seems to suggest that the hinge sections were located precisely at the critical sections in this instance. However, it must be pointed out that the accuracy of measurement was not so good in this instance, as is evidenced by the check with external equilibrium in Fig. 22. This diagram indicates that all of the hinge moments should be slightly larger in value than shown in Fig. 21.

It is interesting to note the way the curve of M_C fell away along the reduction curve once it had reached it. On reaching collapse, however, it began to increase again, due to strain hardening. It will be noticed, from inspection of the predicted collapse mechanism shown in Fig. 20, that the end panels have been deflected upwards to accommodate a downward deflection of the two central panels. This is a result of assuming that all members are inextensible. However, reference to Fig. 19 shows that, in the actual truss, there was a finite extension (or compression) of chord members, which allowed all panels to deflect downward.

CONCLUSIONS

In conclusion, it can be said that the simple theory, modified for axial stress, gave a close prediction of the collapse load and moments of this truss. In none of the trusses described was the difference between experimental and theoretical collapse loads greater than 6 per cent. However, the plastic theory calculations as applied to these trusses, did not adequately describe their limiting moment behaviour. This was largely a result of assuming that plastic hinges must be located at critical sections and must develop moments at collapse equal to the M_p value of the section. In actual fact, some of the joints of the trusses (the L-shaped joints) were inadequate to develop the moment M_p at the critical section without allowing large relative rotation. Other joints (some of the T-shaped joints) were able to develop higher moments than M_p at the critical sections before severe plastic rotation occurred. This therefore emphasises the need to consider characteristic joint behaviour in a plastic design, if the design is expected to be an accurate estimate of the structure's strength. While some investigations of such characteristic behaviour have already been carried out,[2, 3, 5] there is still a lack of information of the type that could be used in design. It is to be hoped that future researches in the plastic theory will soon remedy this.

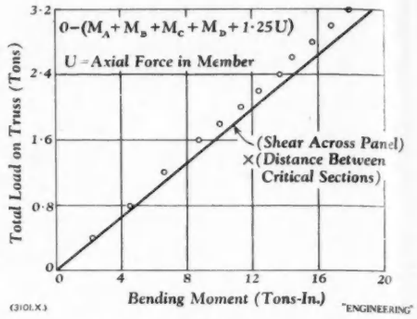


Fig. 22 External equilibrium check, truss 6PA. The measured hinge moments are all smaller than was to be expected.

Acknowledgment.—The work described above was carried out in the Department of Civil Engineering, King's College, Newcastle-upon-Tyne, University of Durham, of which Department Professor W. Fisher Cassie is the Head.

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LUBRICATION EXPLAINED

Three Informative Films

Three informative films on the subject of industrial lubrication were recently shown by the Vacuum Oil Company, Limited, at the British Council Cinema, Hanover-street, London, W.1. They are the first of a series which is to form the nucleus of a European Industrial Film Library established by the company.

The first film, "Lubricating Greases," illustrates the importance of these materials in industry and shows examples of the many types in use. The necessity for correct manufacture under carefully controlled conditions is stressed; the advantages of using the correct grease are demonstrated by clear diagrams.

"Cutting Fluids," the second film, shows how this type of lubricant is selected so as to reduce tool wear, prolong the life of expensive tools and increase cutting speeds and outputs. It also explains how a specialist knowledge of metals and the correct choice of cutting fluids results in more continuous production.

In the third film "Thin Film Lubrication," the basic difference between fluid film and thin film lubrication is defined, and the reasons for the different properties required by lubricating oils are explained. The benefits which result from the correct selection and application of lubricants are illustrated by animated drawings.

All three films are 16 mm. wide in black and white and run for about 30 minutes. They can be borrowed direct from Vacuum Oil Company's Industrial Sales Department, Caxton House Tothill-street, London, S.W.1, or from the company's Industrial Divisional Offices.

Two more films—"Direct Engine Lubrication" and "Lubrication of Hydraulic Systems" are being made in France and Germany respectively and are expected to be availabl shortly.

APPLICATIONS OF VIBRATORY ENERGY

APPARATUS FOR DETERMINING ELASTIC MODULI

*By Arnold Graves**

All materials respond to vibrations by actual movement imparted from particle to particle within the mass of the material. Longitudinal pulses applied by a vibrator to one face of a block of material are accompanied by the effects of alternate pressure and rarification characteristic of all sound waves and the material of the block responds to these conditions by a to and fro motion of the particles. The limits of movement are governed by the bond or linkage between the constituent particles, and this bond is of an elastic nature which permits of the movement of the individual particles. Each particle passes through conditions of pressure and of rarification. Longitudinal motion is thus transferred to the "immediate neighbour" particles and so on from layer to layer, as it were, throughout the mass of the specimen to appear at the opposite face of the block as longitudinal movements of the particles forming that face.

By means of suitable attachments similar to gramophone pickups, these pulses can be converted into electrical equivalents which can be amplified for study on a meter.

NON-DESTRUCTIVE TESTING

Tuning forks, organ pipes and musical instruments will emit notes of constant frequency and of slowly "damped" persistency if shock tactics are employed in such a manner as to set the relevant component into vibration at the frequency which corresponds with the natural frequency of vibration of that component. This so-called frequency of resonance is dependent on the geometry and the density of the material or materials, and therefore is intimately associated with the elasticity of the constituent particles. All materials, solid, liquid or gaseous, respond in this manner and their elasticity can be determined as a function of their density, goemetry and resonance frequency. Thus, for example, in the case of concrete, Young's modulus of elasticity, E, neglecting the almost negligible corrections for the interaction of transverse waves, is given by

$$E = 6 \times 10^{-6} n^2 l^2 w.$$

where

- E = Young's modulus of elasticity (pounds per square inch)
- n = frequency of resonance (cycles per second)
- l = length of concrete specimen (in.)
- w = density (pounds per cubic foot).

* Of K. C. Productions, 184 New Kings-road, Fulham, London, S.W.6, who are the makers and co-patentees of the apparatus described in the article.

The fact that the elastic modulus of all materials can be obtained by a non-destructive method offers very good opportunities for the continuous study of materials subject to various conditions of ageing.

In the case of building and road materials, concrete or other beams may be subjected for periods to an intensified reproduction of the various conditions under which they may have to operate in practice—friction, impact or vibration, bending or other strains, freezing, water erosion, chemical erosion, etc. The useful life of a beam under such conditions can be determined as an actual fact rather than as a prediction, since the individual tests can be carried out without changing the test-piece. Useful life can be determined by the simple process of monitoring any changes that may take place from time to time in Young's modulus.

It should be noted at this stage that the electrodynamic method of testing concrete was developed into a practical proposition by the Road Research Laboratory of the Department of Industrial Research and is now accepted as a standard method by the British Standards Institution (B.S. 1881 : 1952). Similar work has been progressing for a period of years in the Physics Division of the National Physical Laboratory, not only in connection with road materials, but with a variety of other materials, including metals, and at the present day this work is spreading to many research units, not only in the universities and polytechnics, but also in industry. It is clear therefore that the applications of supersonic and audio-frequency vibrations is becoming more widespread in the fields of research, test and production. It is felt that, as knowledge increases and spreads, the accurately controlled generator of variable-frequency pulses will become a general-purpose instrument in many branches of research and industry.

INDUSTRIAL PROCESSING

The Building Research Laboratory has produced a film for the express purpose of depicting the disorderly sequence of rotational and other movements tending towards separation, which appeared to be the inevitable accompaniment of any process of moulding cement and concrete cubes under unsuitable conditions of vibration. It appeared evident from the demonstration that order replaced disorder only when exact optimum frequency of vibration was imparted to the mould during the process of setting from the liquid to the solid state. This case is one out of many that could be cited as strong supporting evidence of the trend of informed opinion towards matching an exact optimum frequency to each particular material and operation. Existing "brute force" methods of vibrating, stirring, mixing, etc., will give way to the gentler but more effective methods of applying the exact frequency which will, in most if not all cases, complete any specific operation in the shortest time and with the greatest efficiency.

Research alone will define the limits of the fields of applications of these methods, but successful research will be justified in all cases by economies in the costs of production, the more so where this is accompanied by an increase of efficiency in operation. It is impossible to foretell in detail the numerous industries that will benefit from research in this field, but, apart from industries in which a basic operation consists of the mixing or separation of large particles, it appears probable that advantageous methods could be applied in processes involved in the manufacture of paints, emulsions, detergents, cosmetics, dyes, colloidal solutions, and in fact many chemical, pharmaceutical, and food products.

It must not be thought that applications of sonic and supersonic vibrations are restricted to the above limited fields. These, along with many other applications to research and industry, have been summarised in the table which accompanies this artcile. "Sonics" and "ultrasonics" cannot, at this stage, be accepted as panacea for all problems of mixing and blending: many industrial applications are not to be recommended at present until the unpleasant and possibly harmful noise with which they are accompanied is, by suitable sound insulation, kept within confines. The many marine and sound-ranging applications, developed in two world wars, have been omitted from the table, as being already well-known. For the same reason no reference has been made to the "blind flying" methods of bats. We must, however, acknowledge that much that is known to-day is the outcome of highly concentrated research on these subjects during the war.

An essential feature of many forms of apparatus for applying ultrasonic or audio-frequency vibrations is an electronic variable-frequency generator. These oscillators usually comprise a self-contained power amplifier and can therefore provide the necessary power to drive some type of vibrating unit which can apply pulses of suitable form, amplitude and frequency to the object of the experiment.

BEAT-FREQUENCY EQUIPMENT

One of the more complicated applications of vibration techniques is that of determining Young's Modulus of Elasticity by electrodynamic methods, and the best way of establishing a picture of the general working of the principles involved will be to discuss in detail equipment specifically designed for this purpose. It should, however, be understood that the basic tool for many operations suggested by this article is the variable-frequency generator with amplifier and vibrator, and means must be provided to assess with complete accuracy the exact frequency which is being applied. Reference to the

APPLICATIONS OF VIBRATORY ENERGY

MECHANICAL AND ELECTRICAL ENGINEERING			CIVIL ENGINEERING			CHEMISTRY, BIOLOGY, ETC.		
TEST AND RESEARCH	TOOLS	PROCESSES	TEST AND RESEARCH	TOOLS	PROCESSES	TEST AND RESEARCH	TOOLS	PROCESSES
Elasticity Moduli	Aluminium Soldering	Difficult Alloy melts	Elasticity Moduli	Mould Vibrators	Substrata Identification	Viscometry	Particle Separation	Emulsification
Flaw Detection	Drilling Glass, etc.	Electro-plating	Flaw Detection	Sieve Vibrators	High-speed Well Drilling	Relaxation Studies	Homogenisation (of Milk, etc.)	Coagulation
Thickness Gauging	Sieving Vibrators	Cleansing Small Components	Tracing Conduits	Immersion Vibrators	Air and Gas Cleansing	Gas and Liquid Analysis	Variable Frequency Vibrator	Dispersion
Vibration Analysis	Variable Frequency Vibrator	Laundry Vibrator	Vibration Analysis	Variable Frequency Vibrator	Control of Dangerous Gas Mixtures	Cavitation Studies	Cavitation Equipment	Enzyme and Vaccine Extraction
Quality of Castings	Acoustic Transducer	Refining Slurries	Viscometry	Sonic Siren Generators		Carbon Dioxide Content in Air	Tissue Therapy	Bacteria Killing
High Polymer Studies		Pressure Control	Velocity Studies			Reaction Rates	Jet Transducer	Fine Particle Separation
Resonance Studies		Batch Counting	Fire-damp in Mines			Catalytic Reactions	Siren Transducer	

equation for Young's modulus of elasticity given earlier will show that frequency is the most significant contributing factor as any error in this figure will be squared, leading to an unacceptable error in computation.

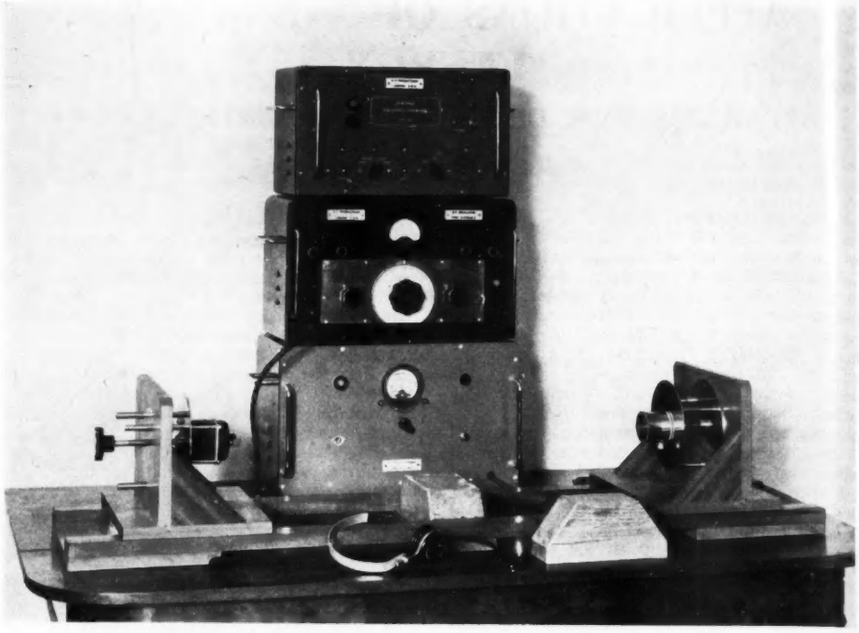
Electronic equipment higherto employed in electrodynamic methods of determining the elastic properties of metals and non-metals are open to the criticism of being either expensive and perhaps unduly elaborate in response to a demand for a high degree of accuracy, or relatively cheap and subject to limitations which may lead to substantial errors of discrimination on the part of the operator or to non-compliance between the instantaneous frequency and the calibrated indications of the instrument.

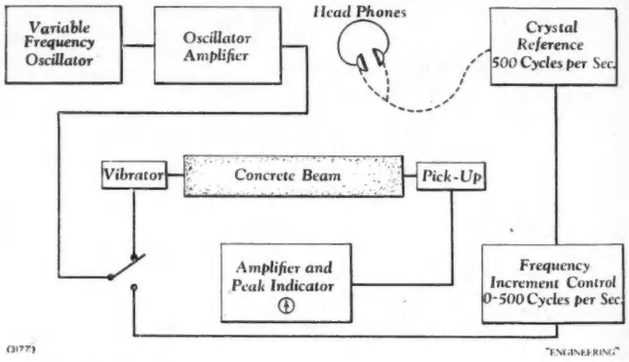
Equipment in the first or expensive category usually combines a variable-frequency oscillator with an external precision type of electronic computer or scaler. "Gating" circuits are employed for the purpose of switching the scaler into action for a predetermined period of time, the system being such that the computer counts the actual sine waves in the output to the vibrator. Thus a reasonably exact result is obtained by dividing the number of pulses by the elapsed time. The cost of this portion of the equipment alone may well exceed £1,000. The timing circuit cannot claim any degree of precision if based upon the unreliable frequency of the mains or upon any local oscillator which may be subject to frequency drifts, and the electronic computer or scaler and its environment must be of the rare type which combines a high counting rate with provision for the minimising of spurious counts. These requirements can be met by an equipment which comprises a variable oscillator of reasonable long-term stability, a timing or "gate" circuit embodying a crystal-frequency standard oscillator, a high-grade scaler counting up to say six digits, an output amplifier, and an applicator or vibrator, all followed by a pick-up and its associated amplifier and peak-reading meter. In many cases a fully screened operating enclosure with specially filtered mains will have to be provided as a precaution against the intrusion of spurious counts due to "spikes" on the mains or to electrostatic or electromagnetic pick-up of strong local field surges. Complete immunity from spurious counts cannot always be guaranteed.

What was required was a simplification of the equipment which gave promise of comparable accuracy, as this would greatly reduce not only the cost of the apparatus but also the liability to breakdown which always exists where many valves and their associated circuit components are involved. It was finally decided to employ a system based on reference to a standard frequency as a function of the actual frequency determination, and not merely as an act of calibration checking. Substantial errors of the first order are thus eliminated and second order errors depend on the operator's ability to manipulate a control so as to obtain an approximation to "zero beat" in a pair of headphones. Since careless handling will at most represent an error of a fraction of a cycle per second it can be claimed that this method of approach has led to the design of an instrument which has a high degree of accuracy at a relatively low cost. This instrument and its block diagram are illustrated on this page.

One production form of the instrument consists of a crystal-frequency standard oscillator intimately associated with a beat-frequency oscillator, an output amplifier, a vibrator or transducer, a pick-up and amplifier with meter to indicate when the resonance frequency of the test specimen has been attained. It will be appreciated that all these instruments in one form or another are common to the more elaborate type of instrument already referred to, and that a considerable economy has been effected by dispensing with the electronic computer and "gating" circuits.

A beat-frequency oscillator has been selected as being a type which is relatively cheap to produce and capable of covering a wide range





The non-destructive testing of materials can be accomplished using beat-frequency apparatus. That shown in the illustration and block diagram has been designed specifically to determine Young's modulus for concrete, and gives results to much higher degree of accuracy than is obtained with mechanical testing.

of frequencies without a complicated switching system. This type of instrument is particularly suitable for the range of 0 to 20,000 cycles per second, which is the required operational range for applications to concrete research. The beat-frequency oscillator functions by "heterodyning" or "beating" together two distinct frequencies, the one a fixed frequency and the other an overlapping variable-frequency wave train, in a so-called mixer circuit. If, for example, the fixed frequency is 100,000 oscillations per second, and the variable frequency can range between 100,000 and 110,000 cycles per second, the frequency that will emerge can be varied at will from 0 to 10,000 cycles per second. Thus, if the main frequency control knob is set at a frequency of 2,350 according to the position of its pointer in relation to its calibrated dial, it will actually set the variable radio-frequency to 102,350 cycles, producing an audio-frequency difference of 2,350 c/s as the difference in frequency between its frequency (102,350 cycles) and that of the fixed oscillator which produces a constant frequency of 100 kc/s. The frequency that emerges is always the difference between the constant 100 kc/s and the actual radio-frequency corresponding to the position of the main frequency control knob.

The employment of a variable-frequency oscillator of the above inexpensive type becomes possible only in a system in which long-term stability is not a matter of great moment. This is the case in the present system, in which the actual frequency reading is at all times obtained by immediate reference to a frequency standard of accepted reliability. It should also be noted that it is easy to cover a frequency range of 100,000 c/s to 110,000 c/s with short-term exactitude by one continuous movement of a single knob, thus making it possible to control the resultant difference frequency by a dial calibrated in terms of 0-10,000 c/s. Increases of range can be provided by various expedients of which the simplest is based on the provision of means for decreasing the frequency of the fixed frequency oscillator in accurate steps of 10,000 c/s, thus increasing the difference or output frequency by a constant factor of 10,000 cycles for each such increase. This has the advantage that the calibration of the dial remains the same for each range, since the circuit constants of the variable radio frequency have not been altered. Thus the same control and dial can cover frequency settings from 0 to 10,000 c/s, from 10,000 to 20,000 c/s and so on.

REFERENCE FREQUENCY

A frequency-standard oscillator is an essential component of the system, and a crystal controlled oscillator has been selected in preference to a valve-maintained tuning fork in view of its well-known integrity and other advantages. A crystal oscillating at a fundamental frequency of 1 Mc/s is employed in conjunction with "divider" circuits, each of which subdivides by an exact factor of ten. Thus frequencies of 1,000,000, 100,000, 10,000 and 1,000 c/s are available at will. Each of these frequencies is fixed and constant to within 50 parts in a million.

The frequency-standard oscillator is directly associated with the variable-frequency oscillator in such a manner that the following sequence of operations can be carried out in swift succession. In one position of the control switch the variable

frequency becomes independent of the crystal oscillator and is directly connected to the vibrator which is in contact with one end of the specimen. A careful rotation of the variable-frequency control knob will find the frequency of resonance of the concrete or other specimen. The condition of resonance will be indicated by an abrupt movement to a peak reading on the part of the pointer of the meter on the pick-up amplifier. The position of the control switch is now immediately changed so that the sine-wave frequency of resonance of the specimen is diverted from the specimen to the crystal standard oscillator so as to heterodyne with the latter. Headphones plugged into the crystal oscillator are used to monitor the heterodyne note. A special fine adjustment for the frequency, to increase the frequency by unit increments up to a maximum of 500 c/s, is now cautiously rotated until a condition is reached where the beat notes heard on the headphones become evident as single pulses only occurring at time intervals of more than a second. A pointer and calibrated dial associated with the special frequency fine-adjustment knob will indicate the number of cycles per second which has to be added to bring the two frequencies to equality. By subtracting the number thus indicated from the crystal-oscillator harmonic frequency the true frequency of resonance is obtained. The exact reference-frequency harmonic in question is always made evident by the position of the variable-frequency control pointer. In each case it will be the nearest harmonic beyond the position of the variable-frequency control pointer.

In the range between 1 c/s and 20 kc/s harmonics appear at each kilocycle per second with intermediates at each intermediate 500 c/s position. Thus reference harmonics are available at 500, 1,000, 1,500, 2,000, 2,500 and so on up to 20,000 c/s, and the whole range can be sub-divided into discrete sections of 500 c/s each, and any unknown frequency within the range can be determined to a high degree of accuracy by observing on the appropriate dial the number of cycles per second by which the unknown frequency had to be increased to bring it to equality (" zero beat "), with the harmonic immediately above it. Since harmonics are available at every 500 c/s step, it is clear that increase in frequency for this operation will never exceed 500 c/s. This permits calibration with unit definition on a large dial if desired, the more so since the frequency change is linear.

The above frequency exploration is independent of the setting of the main frequency control of the beat-frequency oscillator. When the subsidiary fine-adjustment control is returned to its zero position, the output frequency of the oscillator reverts immediately to the exact resonance frequency of the specimen under test.

The finite accuracy of the system depends on the operator's ability to distinguish the beats at intervals of many seconds. It is, however, pointed out that one beat every few seconds represents a high degree of accuracy at say, 5,000 to 10,000 c/s. Where higher accuracy is called for, an oscilloscope may be employed, as may be the case in " damping factor " problems.

As will be seen from the illustration opposite, an equipment for the non-destructive testing of concrete beams, metal rods, plastic and other materials consits of a wooden frame (in the foreground) with adjustable sliding supports at each end for carrying the transducer or vibrator (on the left) and an electrical pick-up (on the right); the latter is associated with the amplifier (bottom instrument in the background). Test specimens are mounted longitudinally on the central wooden block supports. The middle and upper instruments in the background are respectively the beat-frequency oscillator and the crystal-frequency standard. With little experience it is possible to set up a specimen and determine its modulus of elasticity with great accuracy in a matter of minutes by following the operating instructions previously described in this article.

HIGH-SPEED SCALE-FREE HEATING OF STEEL

CONTROLLED ATMOSPHERE AND LOW HEAT LOSSES

Experiments have shown that if an open-type furnace can be operated with from 12 to 16·5 per cent. of carbon monoxide in the heating chamber the scaling of steel being heated falls practically to zero. In an orthodox furnace, however, it is not practicable to maintain the required temperature if the CO content exceeds about 6 per cent.

The " Equiverse " furnace, introduced by the Incandescent Heat Company, Limited, Cornwall-road, Smethwick, Birmingham, is designed to use an excess-CO chamber atmosphere and at the same time to work to the degree of heat required for dealing with steel. It has a controlled atmosphere containing 14·5 per cent. of CO in the chamber, and the heat value in the CO is recovered by burning it in two regenerators in which the combustion air is heated to between 900 and 1,000 deg. C. The accompanying illustration shows the " Equiverse " system applied to a furnace with a hearth of 12 sq. ft., and designed to operate on town gas. Such a furnace would be ideal for such work as billet heating for a variety of operations, but the system is by no means confined to one type of furnace or fuel. It can be applied in single or multiple units to almost any type of furnace working over a temperature range of 1,100 to 1,500 deg. C. or over, and is adaptable to most liquid and gaseous fuels. Typical applications are to drop-forging furnaces, stationary or continuous furnaces for heating or heat treatment, and rotary-hearth furnaces.

The system operates with a slight positive pressure within the furnace chamber, which ensures that atmospheric air from outside is excluded. Combustion of the fuel with a restricted air supply gives a high CO content, and the chamber atmosphere is therefore completely non-scaling.

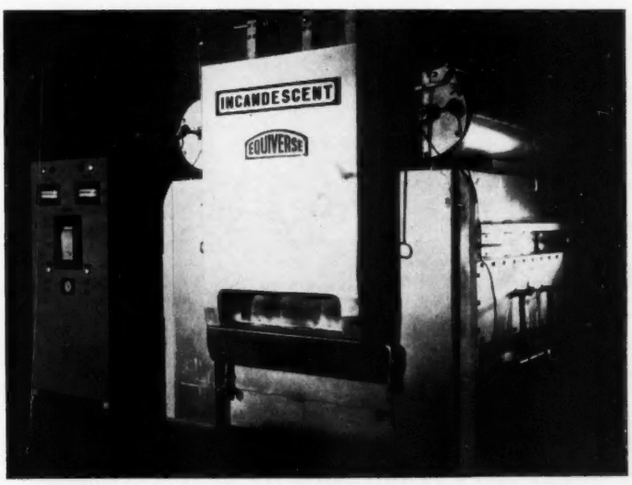
Combustion products pass to one of two reversing regenerators mounted, on the furnace illustrated, on the top of the casing. The regenerators each consist of a stack of nickel-chromium cast tubes of small diameter, in casings of simple design which give easy access for inspection and maintenance. Induced and forced-draught fans are provided, and the combustion products, after passing through the regenerators, are discharged into a small stack on the top of the furnace. The temperature of the waste gases does not exceed 200 deg. C. A hood over the furnace door traps any combustion products which may escape when the door is opened, and leads them to whichever regenerator is on air at the time.

Reversal of the waste gas and air flow in the regenerators is controlled by butterfly valves which are operated by compressed air, and controlled by solenoids and an electric timer. Normal flow-reversal is at one minute intervals. As alternatives to air operation, electric or hydraulic control of the valves can be supplied if required.

The controls are housed in a cabinet which can be in any convenient position. This cabinet is equipped with push-button start and stop controls for the induced and forced-draught fans; signal lights show if these units are operating. The cabinet also houses two indicating pyrometers, one for each of the regenerators, with signal lights to show if the unit is on heat or air, and a recording temperature controller for the furnace chamber. An electric timer mounted in the front of the cabinet controls the flow reversal. The reducing atmosphere in the furnace chamber is maintained by means of a recorder showing the amount of carbon dioxide in the stack gases. A CO_2 figure of about 4·5 per cent. in the stack gives the required atmosphere in the chamber, and this figure is maintained by automatic adjustment of the fuel and air supplies.

A typical output obtained from the furnace illustrated, working on town gas at 450 B.Th.U. per cubic foot, was 72 billets of mild steel heated to 1,180 deg. C. per hour, with a gas rate of 2,400 cubic foot per hour. The billets weighed 15 lb. each, and the throughput was therefore at a rate of 1,080 lb. of steel per hour. The scaling during heating was nil, as determined by extracting sample billets in a tube containing dry nitrogen and allowing them to cool in this gas. A typical heating rate with cold billets 3 in. in diameter and 5½ in. long was to 1,250 deg. C. in 13 minutes, and to 1,280 deg. C. in 17 minutes.

A billet withdrawn from the furnace will, of course, commence scaling immediately it comes into contact with the shop atmosphere, though it is possible to prevent this scaling if special conditions make it necessary or desirable. For normal forging or other hot working, such an arrangement would not be necessary, the amount of scale formed in the short time required to transfer the billet from the furnace to the next stage in the process being so small as to be of no consequence. The advantages of being able to deliver a billet in practically scale-free condition are obvious. The loss of material is reduced, dies and other tools have a longer life, and the quality of the finished product is improved. In addition, the life of the furnace-hearth refractories is increased by the absence of scale in the furnace.



Economical high-speed heating in the temperature range 1,100 to 1,500 deg. C. or above, with complete absence of scaling, are features of the " Equiverse " furnace system made by the Incandescent Heat Company, Limited.

COMPUTERS APPLIED TO ENGINEERING DESIGN

SOLVING MECHANICAL AND AERODYNAMIC PROBLEMS

" Some Applications of a Digital Computer to Gas Turbine Engineering " was the subject of a lecture given by Mr. G. C. Best, Orenda Engines Limited, Canada, before the Birmingham branch of the Royal Aeronautical Society on September 23. In the first part of the paper, Mr. Best described in some detail the equipment in use at Orenda Engines Limited—the IBM card-programmed calculator, a machine of the electronic digital type fed by punched cards. The main part of the paper, an abridged version of which is given below, dealt with the application of computing techniques to various turbo-jet design and development problems. Discussing the operation of a computer section, Mr. Best said that to ensure that the person with the most intimate knowledge of the problem performed the detailed mathematical steps, made valid assumptions and took any short cuts that were justifiable, Orenda engineers programmed their own calculations for the computing machine. In conclusion, Mr. Best discussed possible future trends.

MECHANICAL DESIGN

A number of mechanical design calculations require tedious step-by-step methods in which the calculations must be repeated as the shape of the part is progressively refined. One of the earliest applications of the electronic computer to mechanical design at Orenda Engines Limited was of this type—the stressing of a disc, with the result that all disc design can now be done by one man.

At the rim of the disc, the temperature and the radial stress due to the blades are known; between rim and hub, a temperature distribution in line with previous experience is assumed and at the hub, the radial stress is usually known. Starting at the hub with an estimated tangential stress, the differential equations for centrifugal stresses are evaluated step by step to the rim, giving the particular integral. The thermal stress equation is then evaluated step by step for the given temperature profile. If the system remains linear, the sum of these two solutions plus a complementary function multiplied by a constant must satisfy the boundary conditions of radial stress at the rim. The complementary function is readily obtained by a second evaluation of the centrifugal stress equation with a different tangential stress at the hub. These calculations require approximately ten minutes of computer time.

If the disc stresses are high enough to cause plastic strain, the amount of this strain is estimated, and inserted into the thermal stress equation. A new solution for the stress distribution is obtained, and a second estimate of plastic strain made. This iteration is continued until the assumed strain is consistent with the calculated stress distribution.

The electronic computer allows the designer to investigate these effects for a number of disc profiles and operating conditions if desired, without delaying other design work and with confidence that arithmetical or accumulated graphical errors do not affect the results.

Other calculations which have demonstrated the usefulness of automatic calculation both in time saving and in the reliability of the results are blade stressing, shaft whirling speeds, control system linkages, and disc vibrations.

The storage and sorting features of the IBM card system are particularly useful in the field of engine records. Individual cards can be used to store parts data such as part numbers, assembly number, quantity required per engine, material, weight, moment about reference axis, polar moment (if rotating part) and so on. A deck of these cards constitutes the master parts list. In a matter of minutes, the effect of redesigned parts on engine weight, centre of gravity, polar moment, and material requirements can be determined. An alphabetic printing feature also enables a working parts list to be printed directly by the tabulator, thus eliminating stenographic errors.

AERODYNAMIC DESIGN

One of the more tedious jobs in aerodynamic design which has been greatly expedited by automatic calculation is the specification of the blade aerodynamic shapes for manufacture. At Orenda Engines Limited a system of rectangular co-ordinates has been adopted in which the blade cross-sections or profiles at various radial stations about an inch apart are defined by co-ordinates with respect to x and y axes respectively parallel and normal to the blade chord (see Fig. 1). The relationship between the sections at different radii is determined first by a radial " stacking line " through the centre of the blade root, intersecting each x-y plane at a stacking point; and second by a twist angle of the chord line or x-axis with respect to the centre-line of the blade root. The co-ordinates of the stacking point are the same in each x-y plane, since the twist of the co-ordinate system is about the stacking line.

In order to calculate the co-ordinates of the blade profiles in this system of axes, polynomials were developed which accurately fit the front portion (up to 0·4 chord) and the rear portion of the basic uncambered C7 and T6 aerofoil sections. Since the relationship between the profile and the stacking point is not known immediately, the co-ordinates are first calculated, in the case of a compressor blade with circular arc camber line, with respect to the mid-point of the arc.

The position of the centroid of the profile is then obtained from a generalised expression for the C7 aerofoil section in terms of thickness/chord ratio and camber angle. The principal moments of inertia, the points of maximum fibre stress, the gas bending moment and centrifugal stress are then calculated, and from these the offset of the centroid from the stacking line required to minimise the peak stresses is calculated. The knowledge of this offset plus the co-ordinates of the stacking point (which are merely selected to make all the profile co-ordinates positive) is sufficient to permit recalculation of all the co-ordinates with respect to the final axes.

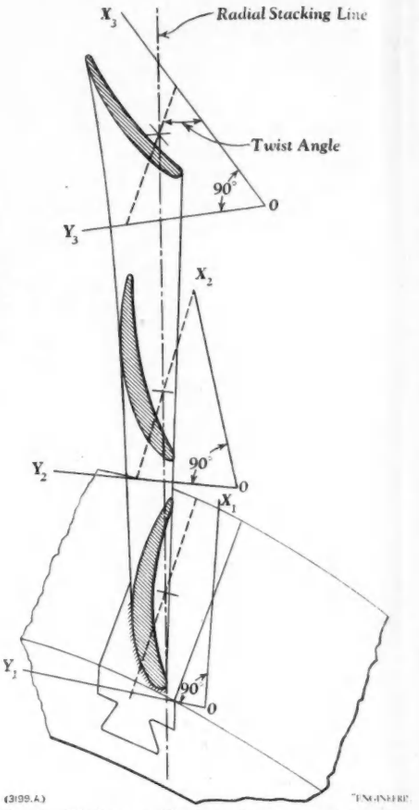


Fig. 1 Blade co-ordinate systems on a compressor rotor blade.

Present practice at Orenda Engines Limited is to design the low-limit blade profile, and allow a constant thickness tolerance band around it, except at the leading and trailing edges which are determined by a different tolerance on the blade chord. The co-ordinates of the high-limit profile are thus easy to obtain except at the leading and trailing edges, where a special calculation has been programmed to obtain the new radii and centres of the leading and trailing edge circles.

From the blade pitch and stagger angle it is possible to obtain the position of an adjacent blade in the same row and calculate the throat area between two blades. The calculation consists of approximating the profile by about a hundred straight line segments, calculating the slope of each line, then sorting to find the lines which have equal slope. The slope of the lines joining these parallel elements on adjacent blades is then obtained and checked against the slope of the elements themselves. The one nearest to being perpendicular is taken as the throat width. The practice of using five significant figures in the profile co-ordinates, which was established to avoid scatter in large-scale inspection charts, proved useful here in allowing the slopes of surface elements to be calculated to three significant digits.

THERMODYNAMIC STUDIES

Thermodynamic studies include investigations of various basic engine cycles over a variety of pressure ratios, combustion temperatures, component efficiencies etc.; the calculation of tables of the properties of combustion products for

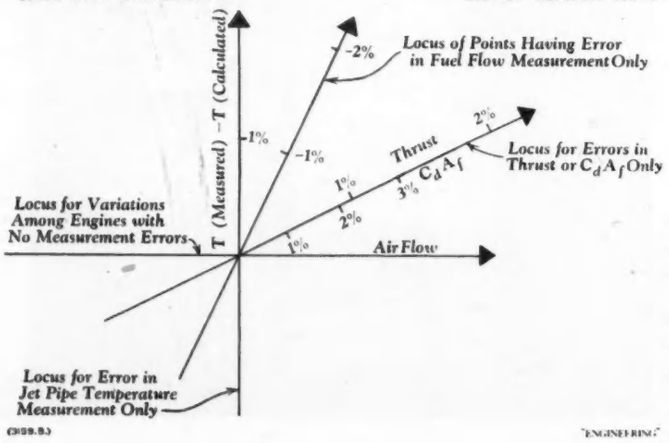


Fig. 2 Co-ordinate system for production-engine error analysis. C_d = discharge coefficient, A_f = final nozzle area (sq. in.).

various fuels, and the prediction of off-design engine performance from component characteristics. The latter calculation is of particular interest as a computer problem because it involves empirical functions of two variables. In a computer of limited high-speed storage capacity, such as the IBM card-programmed calculator, it is necessary to store and read the component characteristics externally. This has been done by an operator who obtains the calculated X and Y from the printer of the tabulator, reads $z = \phi(x, y)$ from a graph, and inserts it into the next calculation by means of a keyboard. Although the operator may exercise discretion during the calculation to improve results, he remains the slowest link in the problem. More rapid solutions can be obtained on a computer with sufficient high-speed storage for a grid of x, y values, each combination with its appropriate z. Magnetic drum storage is satisfactory in this respect. During a calculation, the grid points nearest to the desired point are read out of storage, and interpolation is performed to obtain the desired result. This type of calculation has been done on the Ferranti computer at the University of Toronto. On this machine approximately 0·6 second is required to obtain the nine nearest grid points, and perform second-order interpolation among them—at least ten times faster than the human operator using the graph and keyboard.

DATA REDUCTION AND ANALYSIS

The data from flight tests, development and production engine tests, wind tunnel tests and rig tests of various types require correction for instrument errors and varying amounts calculation or reduction before the significance of the results can be appreciated.

A large volume of input data upon which relatively simple mathematical operations are performed is typical of this field of calculation. The main problem is to get the data from the test area to the computer in the proper form and in the shortest possible time. Since the data must eventually be converted to digits for calculation, instruments are designed with digital output where practical, as for example, electronic counters for r.p.m. and fuel flow indication, digitisers and automatic printers for self-balancing potentiometers, and counters on position indicators. These instruments are compatible with future systems which will record data automatically in a form suitable for direct insertion into a computer.

At Orenda Engines Limited, some data from potentiometers are automatically tabulated, but because of the limitations on high-speed storage in the present computer (preventing quick access to any quantity of correction factors) corrections are applied manually. This also affords an opportunity for a review of the data to eliminate any obvious errors, and to sort out any changes in the instrumentation.

Reduced values of thrust, jet-pipe temperature, specific fuel consumption at the rated speeds, the final nozzle area, engine number, date, test cell number and other identifying data are punched on cards, one for each acceptance test run of each engine build. A check calculation is done first to compare the measured jet-pipe temperature with a value calculated from the equation for momentum at the final nozzle, and a simplified expression for the temperature changes through the compressor, combustor and turbine. The results of these calculations may be plotted on the co-ordinate system shown in Fig. 2. If there were no measurement errors, the measured and calculated temperatures would be equal, and all the points would lie along the air flow axis, with a distribution due to the variations from engine to engine. Since measurement errors exist, however, the points will tend to cover an area around the mean. Any tendency for the spread to be predominantly along one axis identifies the measurement at fault.

To reduce the work of plotting graphs, the above method is now being extended by a machine calculation to determine the centroid of a group of points and their standard deviations about arbitrary axes through the centroid. These standard deviations can then be plotted instead of the points.

FUTURE TRENDS

The course of development of a computing section will depend on the proportion of "design" calculations (in which a lot of calculation is done on a relatively small quantity of input data) and of data reduction (in which the quantities of input and output data are large). Since programmes will be changed frequently, straightforward programming and checking is a requirement for a computer used mainly for design calculations. Speed in the electronic counters and in the transfer of data to and from storage is an asset. This usually leads to storage of part of the programme in the working storage so that instructions will be available more quickly. A relatively small amount of additional storage is required for intermediate results and the occasional empirical curve.

The emphasis in a computer used largely for data reduction should be on the input and output devices, since these will probably control the computing time. The compatibility of the computer input with the output of test instrumentation favours the use of magnetic or punched tape, since these are more adaptable than punched cards to the automatic recording of experimental data. The tapes accept data serially whereas the automatic card punches must store the data and punch the zeros, ones, twos, etc., in order. If automatic recording of data is desired, and punched cards are required for some other reason, such as ease in sorting, the cost of conversion from serial to parallel form must be borne either at the instrument or at the computer.

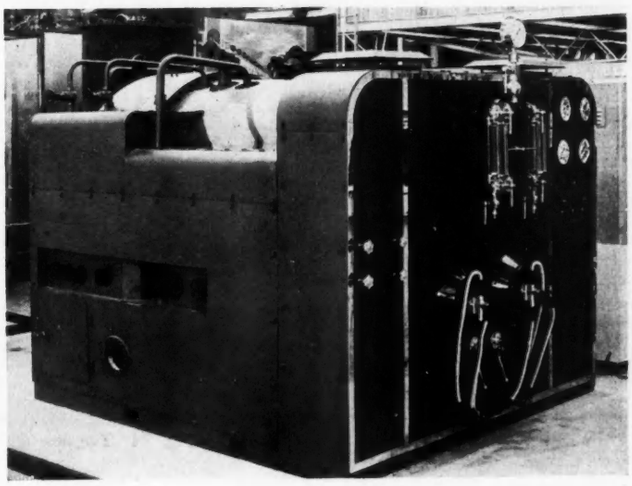
Ample high-speed storage is an asset in a data reduction for the storage of empirical correction curves, and for the rapid handling of data during the calculation. The output of a data reduction computer may be made more intelligible either by the use of a graph plotter, or by statistical and curve-fitting calculations.

OIL-FIRED PACKAGED BOILERS

Models for Light or Heavy Fuel Oil

Two new "packaged" boilers have been introduced by member companies of the John Thompson Group, Wolverhampton. One, the "Minipac," is made by John Thompson Water Tube Boilers, Limited. This boiler has an evaporative capacity of 5,000 lb. per hour from a horizontal flat-ended cylindrical boiler shell 4 ft. 9 in. in diameter and 5 ft. long. It is representative of a range which is being developed for evaporations of from 3,500 lb. per hour and pressures up to 250 lb. per square inch. All the boilers in the range are entirely self-contained, and occupy the smallest possible space; the one illustrated requires 55 sq. ft. of floor space, and has an overall height of 6 ft. The boilers are designed to burn gas oil or Diesel oil, and can also be supplied for burning light residual oils. There are two main flue tubes, with special oil burners giving a short, non-luminous flame, and the two-pass design ensures maximum heat transfer. All the necessary auxiliaries are provided. They comprise feed pumps, stand-by injector, fuel oil pump, and forced draught fan, complete with motor. An insulated casing houses the auxiliaries, and noise is therefore minimised. Fitted doors in the casing allow easy access to the fire tubes and outlet duct for cleaning. The electrical and mechanical controls are mounted integrally with the boiler, and once the required conditions for feed, water level and oil burner have been set, the controls maintain them automatically.

A "packaged" boiler of different design is being made by John Thompson (Wolverhampton), Limited. This is also a fully self-contained unit, with auxiliaries built in, but it is designed to burn heavy fuel oil. It has an evaporation of 5,175 lb. per hour at a working pressure of 125 lb. per square inch, and occupies a space of 16 ft. by 6 ft. by 9 ft. 6 in. high. The boiler is equipped with a rotary oil burner, induced draught fan, feed pump and other auxiliaries, which are controlled automatically from a central panel. The boiler shell is 5 ft. 6 in. in diameter and 10 ft. long. It has a main flue and two rings of fire tubes, the latter serving as second and third passes for the combustion gases. Large circular end doors are fitted for access to the fire tubes. Like the "Minipac," this boiler is self-contained, being built on to a sub-frame, which only requires a flat concrete slab for its support.



This "Minipac" boiler, made by John Thompson Water Tube Boilers, Limited, is fully self-contained, and has an evaporative capacity of 5,000 lb. per hour.

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CHANGES AT RUGBY WORKS

Increased Facilities for Small Turbines

Not only are the British Thomson-Houston Company, Limited, building new works at Larne in North Ireland for the manufacture of turbo-alternators with individual capacities of 30 MW and more, but they are making arrangements to increase the existing capacity for the production of smaller plant at Rugby by altering the lay-out of the buildings, to improve handling and processing, and by installing the latest and most efficient machine tools.

When the Larne factory becomes available, Rugby will concentrate on those sizes for which its plant and equipment are most suitable, turbo-alternators, marine and gas turbines, large industrial gearboxes, compressors and blowers being included in its activities.

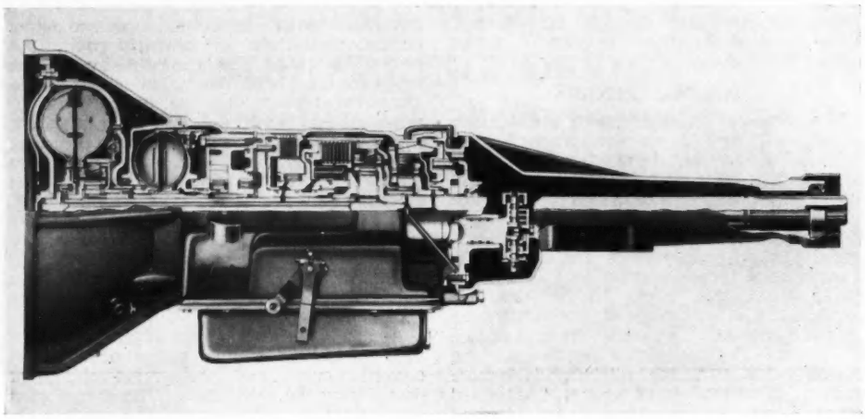


Fig. 23 An example of the complication which is accepted in American transmissions to correct even minor defects is found in the Hydramatic gearbox produced by Cadillac for 1956. In this transmission, which consists of a fluid coupling and four-speed planetary gearbox, changes of ratio can be felt as a slight jerk. In the latest box the drive is initially taken up by a separate fluid coupling instead of by the epicyclic gear clutches. When the coupling is filled with oil, direct drive is picked up smoothly and as the coupling is emptied gear reduction takes over.

The Motor Show at Earl's Court, London (concluded from page 611)

MOTOR CAR DESIGN

CURRENT TRENDS AND PRACTICES: 3—SPECIAL DEVELOPMENTS

The DS19 Citroen ov ershadows all other new cars this year by the boldness of its conception and originality of style. It carries the use of hydraulic power to the logical conclusion by employing it to adjust the suspension system for load variations, to work the steering, clutch and brakes, and change the gears. Hydraulic power is supplied by a seven-cylinder swash-plate pump driven—and this is the surprising detail—by a V-belt. It feeds an hydraulic accumulator in which the fluid compresses a gas separated from it by a rubber membrane.

All four wheels are independently sprung, those at the front from twin parallel arms, those at the rear on single trailing arms. Each wheel is linked to a suspension unit consisting of a sphere in which a gas is compressed by a column of brake fluid under the action of a piston. The fluid in the cylinder acts as a suspension damper and the car is maintained at the same static height regardless of load variations by admitting more fluid from the accumulator or allowing some to leak back. A transverse anti-roll bar connects each pair of wheels and a rod clamped to its neutral point works a simple slide valve controlling the automatic height adjustment. This type of suspension has already given outstanding results when applied to the rear wheels of the old Citroen Six and now, as applied to all four wheels of the new car, it gives a standard of riding comfort and road holding hitherto not obtained with any suspension system.

Disc brakes are used at the front, mounted on the chassis and acting on the front wheel drive shafts; conventional drum brakes are used at the rear. A small button taking the place of a brake pedal operates two separate hydraulic pressure circuits for front and rear brakes, and the distribution of braking effort between front and rear is automatically proportioned according to the load distribution. Unladen, at least 60 per cent. of the weight is on the front wheels, which have larger tyres than those at the rear. The parking brake takes the form of a pedal with a hand locking device, which works the front disc brakes through cables. It could thus be used as an emergency foot brake.

NO CLUTCH PEDAL

The rack-and-pinion steering gear has full servo assistance and appears to lack road feel. The column connected to the single-spoke steering wheel is split, and the driver's effort is normally limited to pressing down the cams on the distribution valves, but if the hydraulic system should fail, a mechanical linkage becomes effective. There is no clutch pedal, the single plate dry clutch being controlled through the small gear lever on the instrument panel. The operating cylinder is filled to de-clutch and drained for re-engagement. A valve connected to the throttle linkage disengages the clutch whenever the engine drops to idling speed. Clutch engagement is also influenced by the accelerator so that the driver can make a gentle or a fierce getaway as required. A hand control permits de-clutching for starting, engine adjustment or towing. The engine starter is engaged by a sideways movement of the gear lever, so the engine can only be started in neutral, and the starter cannot be engaged if the engine is running.

The engine is the most conventional feature of the car, with four cylinders of 1,911 c.c. giving 75 b.h.p. at 4,500 r.p.m. The aluminium cylinder head has hemispherical combustion chambers with valves at an included angle of 60 deg. operated by pushrods and rockers. The carburettor is a twin-choke down-draught Weber on a water heated manifold. The second choke only comes into action when the first throttle is fully opened, a popular modern arrangement which ensures the necessary choke area for full power, while preserving the gas velocity required for easy starting and even slow running. The car has a unit body-chassis structure in steel but all the strength is below the waist line as the roof is a plastic moulding.

Tens of thousands of American cars are now being fitted with refrigeration systems employing Freon gas, a typical circuit for which is shown in Fig. 25 opposite. There are two main methods of installation. Nash mount the whole system under bonnet and front wings, feeding the cold air in at the scuttle, whereas other manufacturers distribute the weight by mounting part of the system in the luggage trunk. The former method places such a load on the front wheels that stronger springs have to be fitted; the latter entails a certain loss of luggage space.

PLASTICS AND LIGHT ALLOYS

Despite a great deal of experimental work on plastics and light alloys, no serious threat has yet emerged to the welded steel car body. This is a pity, because the enormous tooling investment required for a steel body is becoming an impossible burden for some of the smaller manufacturers. Chevrolet made the most serious attempt yet to establish mass production of a plastic sports car body by setting up a 30,000 sq. ft. factory equipped for pressure moulding of 200 plastic bodies a week. The body produced for

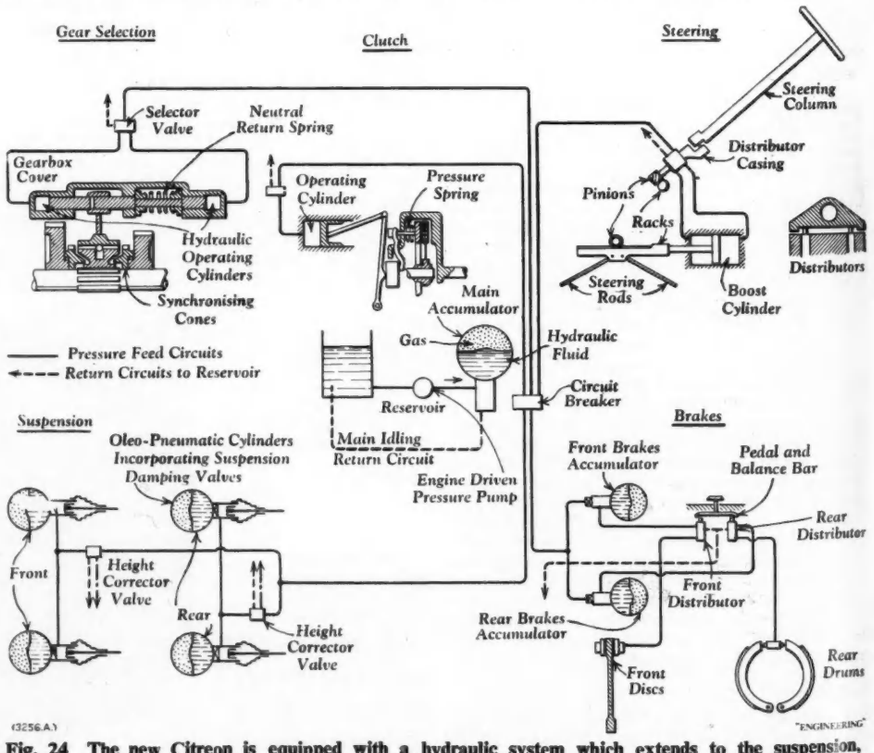


Fig. 24 The new Citreon is equipped with a hydraulic system which extends to the suspension, brakes, gear selection, clutch and steering.

the Corvette sports car weighed 340 lb. of which 136 lb. was glass fibre, 153 lb. polyester resin and 51 lb. filler. A panel thickness of 0·1 in. was adopted as giving a tensile strength equal to steel and having equivalent impact resistance. The car has not sold as well as expected against conventionally built models like the Ford Thunderbird. Minor damage can be repaired by patching and filling but reports suggest that a serious impact produces general distortion which it is extremely difficult to rectify.

LIGHT ALLOYS

The use of light alloy for bodies has received a setback with the fact, not publicly announced, that the French Dyna Panhard now has a steel body structure. One reason was to cut the price, but it is believed difficulties also arose because of inconsistent quality in the spot-welded Alpax structure. Light alloy is however retained for unstressed parts such as doors and boot lid.

In England, Armstrong Siddeley are making extensive use of Hiduminium panels for the new 2·4 litre Sapphire car, drawing upon the experience of the Hawker-Siddeley Group in aircraft production. They have, however, relied upon steel for the body frame.

SAFETY DESIGNS

Up to now car manufacturers have usually avoided talking of accidents and injuries, feeling that this would scare away potential buyers, but American manufacturers, led by the Ford Group, are now boldly selling features designed to minimise injuries to occupants, after long and expensive investigations in which cars containing dummy passengers were deliberately crashed.

Instrument panels are being given smooth padded surfaces and the controls are recessed to avoid the small projections which produce skull fractures when passengers are projected into them. The full-width parcel shelves popular on British cars are rejected elsewhere as a fruitful source of leg and knee fractures. Statistics showing a high rate of mortality to passengers thrown out when doors burst open in a collision have led, in America, to new designs of door lock. Body distortion pulls the normal rotary cam away from the striker plate on the door pillar, so the new designs mount the striker plate on a projecting steel tongue which engages with a strong steel bridge piece attached to the door, as shown in Fig. 26 (*a*) and (*b*).

Some manufacturers are already offering lap straps such as those used in civil aircraft, but they seem to have little value, as the body swings forward from the waist in an impact, bringing the face crashing against the instrument panel. A shoulder harness is much more effective and several designs are already on the market. Given imaginative and vigorous promotion they may well come to be accepted as normal motoring equipment just as the crash helmet is now widely accepted as the sensible wear for motor cyclists.

This new interest in safety comes at a time when manufacturers seem to be on the verge of abandoning the strong steel top, called in America the turret top. The modern roof is a shallow canopy supported largely by glass and easily crushed if the car rolls over. Among compensatory factors, tending to keep the car upright and on the road, may be noted tubeless tyres and power steering, which is gradually permitting the Americans to get accustomed to using fewer than five turns of the steering wheel from lock to lock. Brakes are also improving, particularly in England. Excellent results are now obtained from modern brakes having two trailing shoes with hydrastatic adjustment to keep the friction linings as close as possible to the drum. As they do not rely upon any self-wrapping effect between shoe and drum, these brakes maintain a consistent performance through a wide range of temperature. Driver effort is supplemented by a vacuum servo, the preferred type being known as the suspended

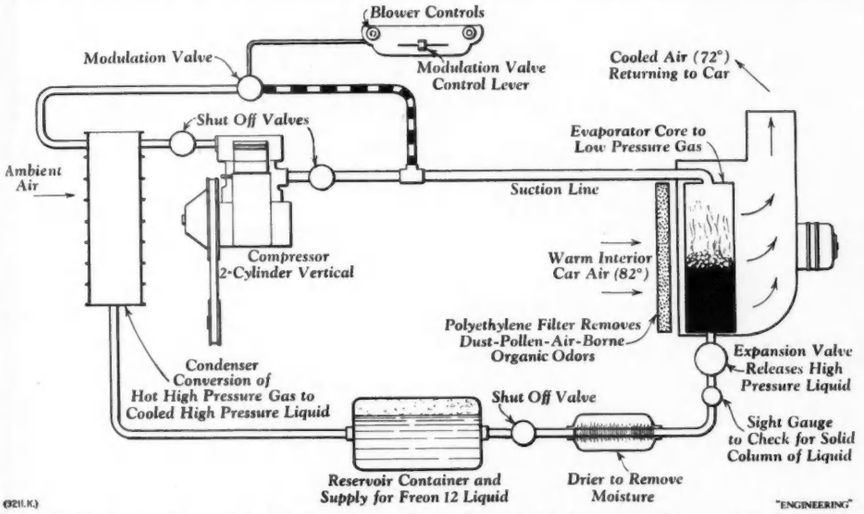
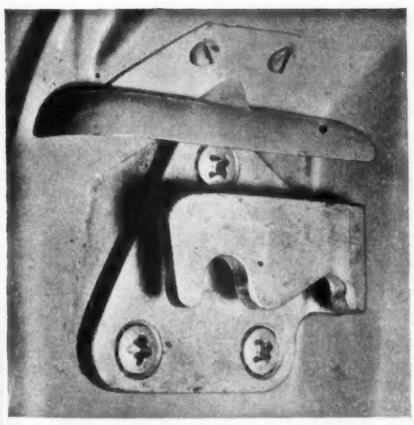
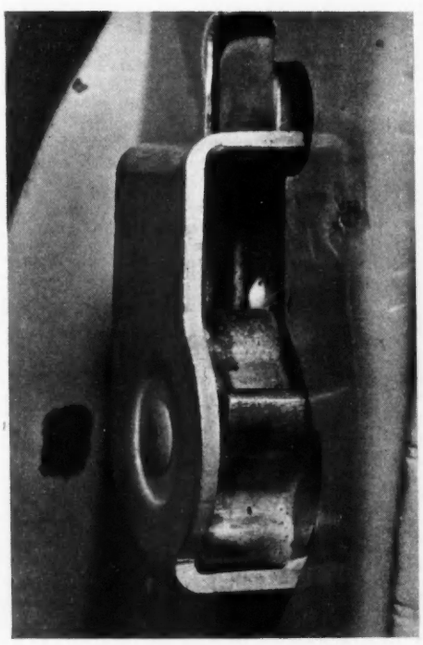

Blower Controls
Modulation Valve
Modulation Valve Control Lever
Cooled Air (72°) Returning to Car
Shut Off Valves
Evaporator Core to Low Pressure Gas
Ambient Air
Suction Line
Compressor 2-Cylinder Vertical
Warm Interior Car Air (82°)
Polyethylene Filter Removes Dust-Pollen-Air-Borne Organic Odors
Expansion Valve Releases High Pressure Liquid
Condenser Conversion of Hot High Pressure Gas to Cooled High Pressure Liquid
Shut Off Valve
Sight Gauge to Check for Solid Column of Liquid
Reservoir Container and Supply for Freon 12 Liquid
Drier to Remove Moisture
G21(L.K.)
"ENGINEERING"

Fig. 25 Diagram of the Lincoln car air-conditioning system with refrigeration. The evaporator may be placed under the bonnet or in a luggage locker.



(a)



(b)

Fig. 26 To prevent doors from swinging open due to body or door distortion in a collision, the Chrysler door-lock striker plate (a) is arranged to engage in a strong steel bridge piece on the door (b). The two components are thus held together even if the door and door frame are pulled apart.

Fig. 27 De Soto car.

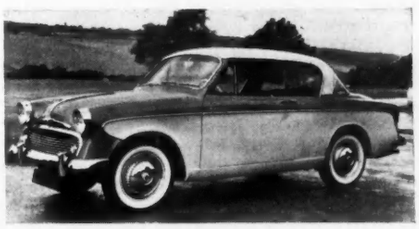


Fig. 28 Sunbeam Rapier.

Fig. 29 American Ford Continental.

Fig. 30 The new Citreon DS19.

Fig. 31 The new 3-cylinder D.K.W. (on the left) is 4 in. wider than the older model. Such a change obviously minimises production problems.

vacuum, in which the air is continuously evacuated from the cylinder by engine manifold depression and air is suddenly admitted when the brakes are applied. This gives quicker results than the simple type in which air has to be sucked out of the cylinder to move the servo piston, and it also allows the servo unit to be mounted further away from the engine.

APPEARANCES

The external appearance of the modern car is undergoing radical change. Important new trends are being established through the constant interchange of ideas between Detroit and the northern Italian coach-builders. A number of British manufacturers appear unwilling to keep in line with these developments and yet seem to have no valid and vigorous alternative to offer. The Chrysler Group has had considerable success in its effort to enlarge its proportion of the American market and its 1956 cars feature rear wings built up to form tail fins. Such a move may be useful if it helps to promote real aerodynamic stability, for American cars at present attain directional stability only through an excessive concentration of weight at the front, accompanied by heavy steering and very slow steering response, defects which are mitigated but not cured by low gearing and power assistance.

The pervasive influence of the current American fashion for breaking up the side surfaces of the car with irrelevant decorations, used as demarcations for areas of two or three colours (Fig. 27), may now be seen on several British cars; at its worst on the Vauxhall Cresta, and somewhat more happily on the Sunbeam Rapier (Fig. 28). When it is a question of appealing to a discriminating public for whom price has no importance, the approach has a remarkable similarity in all countries. The new Continental, the limited-production prestige car from the Ford Group, has conservative lines quite unlike any other American car and has no more chromium decoration than a Rolls-Royce (Fig. 29).

Since it is apparently the intention of Citroen to ignore passing fashion and change their cars once every 10 or 20 years, the styling of the DS19 is of special interest (Fig. 30). The front end is an excellent example of crisp and original design which will obviously remain acceptable for many years. The rear, more cluttered and much less graceful, may profit from second thoughts. It has been erroneously stated that Bertone the Italian coach-builder collaborated on this design; the error arose because one of the Citroen body designers is named Bertoni.

American manufacturers now seem to be prepared to change their bodywork almost entirely at two-year intervals, but present-day tool costs rule this out for European manufacturers making cars in much smaller numbers. An interesting modernisation scheme has, however, been adopted on the German 3-cylinder D.K.W. (Fig. 31) which was virtually cut down the centre line, and reconstituted on a chassis 4 in. wider with a new roof, boot lid, bonnet and radiator grille. Much more could be done to retain the interest of overseas buyers in British cars by designing them so that periodic changes to radiator grille and wing contours would keep them up-to-date in appearance.

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1956 B.I.F.

Electronics Section Introduced

For the first time since the inauguration of the British Industries Fair in London in 1915, the London division of the exhibition will be held during two different periods next year. This innovation has been introduced principally to meet the requirements of manufacturers having an early-year selling season, for whom, under the more normal trading conditions which now apply, a fair in May is too late.

As previously announced in our lists of forthcoming exhibitions and conferences, the first section of the fair will be held at Earl's Court, London, S.W.5, from February 22 to March 2; and the second at Olympia, London, W.14, from April 23 to May 4. The former will be opened by Lady Eden and the latter by Mr. R. A. Butler, the Chancellor of the Exchequer. Simultaneously with the Olympia fair, the customary exhibition of heavy engineering goods will be held at Castle Bromwich, Birmingham. This exhibition will be managed, as previously, by the Birmingham Chamber of Commerce, while British Industries Fair Limited, which took over from the Board of Trade early in 1954, and is responsible for the overall promotion of the fair, will manage the exhibitions at Earl's Court and Olympia.

According to an announcement by the fair authorities at the week-end, Earl's Court will be reserved for the display of consumer goods and has been fully booked, some 450 exhibitors having arranged to occupy the 250,000 sq. ft. of space on the ground floor. The largest section will be that devoted to toys. The British Toy Fair, formerly held at Brighton as a separate show, will on this occasion be organised jointly by the British Toy Manufacturers' Association and the B.I.F. as part of the Earl's Court exhibition.

The fair at Olympia, to which the British Electrical and Allied Manufacturers' Association is giving full support, will include an electronics section as part of the electrical display. It is believed that this is the first time that purely electronics exhibits will be brought together to form a separate section in a British trade fair. Another division at Olympia will be the chemical section, which is being sponsored by the Association of British Chemical Manufacturers. The Association is arranging to hold a conference during this period. The pattern of the B.I.F. of the future, it was stated, might well emerge as that of a " federation of fairs-within-a-fair."

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CONTROLLING EMERGENCY LIGHTING

Cabinet for Battery Systems

The illustration below shows a cabinet which has been designed by Nife Batteries, Limited, Redditch, Worcestershire, for controlling their Nife-Neverfayle emergency lighting sets. These sets are used on pilot systems, where the lamps are only illuminated on mains failure; or on change-over systems, where the lamps are normally supplied from the alternating-current mains but are automatically transferred to a battery when failure occurs.

The cabinet contains a spring-controlled contactor, the coil of which operates in conjunction with a resistance which is fed with direct current from a full-wave bridge-connected selenium rectifier. Operation is controlled within close voltage limits by an auxiliary relay, which switches the resistance in and out. This relay is set so that it will not close until the mains voltage is high enough to close the contactor, thus protecting the coil of the latter and its associated auxiliary rectifier against burn-out.

The cabinet also contains a vacuum-impregnated double-wound transformer with a tapped primary and a full-wave bridge-connected selenium rectifier, by means of which a discharged battery can be re-charged in 14 hours. A further transformer enables the emergency lighting to be fed at a reduced voltage from the alternating-current supply as long as that is available. Except in the largest sizes control is effected from a four-position rotary switch, the charge rate being regulated by two four-position tapping switches for coarse and fine control. Instruments, warning lights and fuses are readily accessible on a sloping panel.

The battery associated with this control cabinet is of nickel-cadmium alkaline cells, and is mounted separately on a single tier stand.

This cabinet for controlling emergency lighting can be used for switching in a separate lighting system or for connecting a battery to the main lighting system.

Fig. 1 The "Cornwall" fueller has a nominal pumping capacity of 400 Imperial gallons per minute; the tank capacity is 3,400 gallons, and the vehicle can tow a trailer giving an additional 2,500 gallons capacity.

FUELLING VEHICLE FOR AIRCRAFT

THE B.P. "CORNWALL"

To meet the higher fuelling speeds required by the latest types of aircraft coming into commercial operation, the B.P. Aviation Service of the British Petroleum Company, Limited, Britannic House, Finsbury Circus, London, E.C.2, have recently introduced a new mobile fueller known as the Cornwall. Designed by the company's engineers, the Cornwall has been developed and constructed by Thompson Bros., Bilston, Staffordshire, on both Leyland and Foden chasses.

The Cornwall has a usable bulk capacity of 3,400 Imperial gallons and is arranged for operation with a trailer which will augment the carrying capacity to a total of 5,900 gallons. It can deliver either gasoline or kerosine fuels and is primarily intended for use overseas. Three are already in use in Switzerland, Denmark and France and further units are being made for use in Europe and Australasia.

The dispensing equipment is of the latest type with a nominal pumping capacity of 400 Imperial gallons per minute and a maximum pumping capacity of 500 gallons per minute, with into-aircraft pressures of 50 lb. per square inch. Thus, the unit is capable of meeting the requirements of all known and projected civil aircraft.

To achieve such a high pumping performance while maintaining a large bulk capacity has necessitated a complete re-design of the conventional aircraft-fueller delivery circuit. The system now employed is the BP low-loss circuit with an auxiliary defuelling facility (for which a patent has been applied) fitted optionally according to the requirements of the particular area where the vehicle will be operating. The adoption of the low-loss circuit enables the vehicle to operate at a nominal 400 gallons per minute with a total circuit loss from pump to hose end of only 30 lb. per square inch.

A general view of the fueller built on the Leyland 19H-7AE chassis is shown in Fig. 1; Fig. 2 shows the operating controls which are symmetrically laid out for ease of operation.

The line diagram of the circuit employed is shown in Fig. 3, which clearly illustrates the "straight-through" nature of the low-loss circuit. Fuel from the two-compartment tank passes via the foot valves into the gallery line and straight into the pump. Delivery from the pump is taken through the pressure control valve, which is of the throttling type, to the Rellumit fine particle filters and thence to the meters and hose reels.

The defuelling operation is effected by applying suction to either hose reel through 1¼ in. Avery Hardoll self-sealing couplings, and delivering back to the tank through the defuelling meter fitted for this purpose.

In addition to the requirement for a maximum pump performance, careful attention has also been paid to ease of maintenance of the equipment. This has largely been assisted by the adoption of a shaft drive for the single-stage Pegson pump. The pump is mounted above the propeller shaft and is direct-driven by a Layrub shaft from the power take-off on top of the main gearbox. The pump incorporates a step-up gear of 2·43 to 1 ratio to allow for operations over the required speed range with suitable engine revolutions. As a result of this arrangement good accessibility is achieved to all the working components in the pump compartment from the near side of the vehicle.

For pressure fuelling at maximum speeds the Cornwall operates with 2½ in. bore hoses, but for overwing fuelling and pressure fuelling within the range of 100 and 130 gallons per minute, 2 in. hoses 100 ft. long are used, which enable four-engined aircraft with wing-tip tanks to be filled from one central position in front of the nose of the aircraft.

The dispensing of aviation fuels calls for the most stringent precaution against ingress of any foreign matter into the fuel. In addition to the provision of fine-particle filtration, the tank of the vehicle is treated with Prodorfilm, a synthetic-resin lining, and the pump and all pipework are hot-tinned.

To assist in maintaining maximum utilisation of equipment the Cornwall is provided with arrangements for bottom loading on either side of the vehicle using the Avery Hardoll 2½ in. self-sealing coupling.

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AWARD FOR AGRICULTURAL RESEARCH

The Royal Agricultural Society of England offers annually a medal together with an award of one hundred guineas for research work of outstanding merit carried out in the United Kingdom, which has proved, or is likely to prove, of benefit to agriculture including agricultural engineering.

No direct application by candidates will be considered, and recommendations for this award should be made by heads of university departments, research stations and institutes and other research establishments. Recommendations for the next award must be submitted to the Secretary, R.A.S.E., 16 Bedford-square, London, W.C.1, not later than January 31, 1956, and must be accompanied by nine copies of a brief statement of the candidate's attainments.

Fig. 2 The operating controls of the Cornwall, which serve two hose reels, are symmetrically laid out for ease of operation.

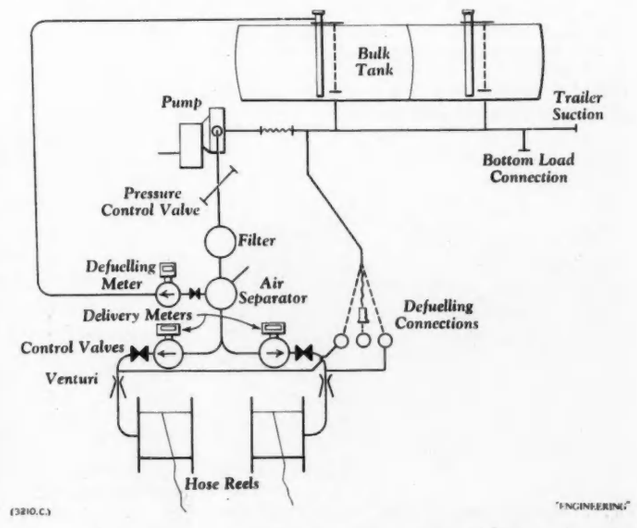

Fig. 3 Arrangement of the pumping circuit.

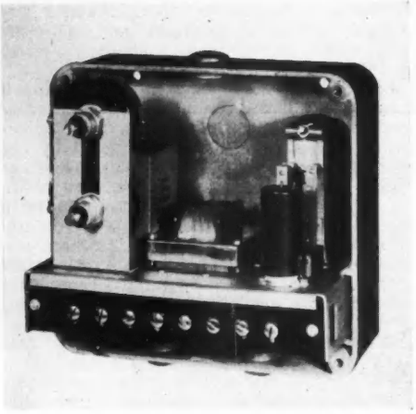

Fig. 1 Infra-red relay for detecting the presence of a hot body at a distance.

DETECTING INFRA-RED RADIATION

Sensitive Electronic Relays

The British Thomson-Houston Company, Limited, Rugby, have recently introduced a new electronic relay in which the sensitive element is a lead sulphide photo-conductive cell. The cell is operated by infra-red radiation from a hot body (even at black heat) and the built-in relay is capable of controlling an external circuit carrying up to 1 ampere at 440 volts alternating current.

The original equipment was developed for use in a steel works, but two models are now available for service under the most arduous conditions. One of these, which is illustrated in Fig. 1 with the cover removed, is capable of detecting a body 4 ft. away at a temperature of 400 deg. C., while a more sensitive type, the detector head of which is shown in Fig. 2, can detect a hot plate at a temperature of 80 deg. C. from the same distance. In both models the speed of response and the sensitivity are stated to be high.

The first equipment consists of two units: a small die-cast box containing the components of the electronic circuits and the Post Office relay, and the detecting head which incorporates the sensitive cell. As it is essential to keep the cell reasonably cool for efficient operation it is contained in a water-cooled housing so that it can be maintained at a temperature of about 60 deg. C. Adequate cooling is thus achieved, even when the detecting head has to be mounted close to very hot bodies, such as white-hot steel.

The second equipment also consists of two units, although the electronic equipment is housed in two die-cast boxes mounted as one. A motor-driven disc is also incorporated in the water-cooled head to interrupt the radiation falling on the cell and thus feed an alternating-current signal to the electronic amplifier.

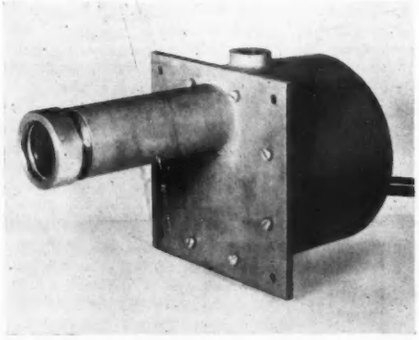

Fig. 2 Detector head of relay, which contains a motor-driven disc enabling an alternating-current signal to be given to the amplifier.

In Parliament

With this issue of ENGINEERING *we commence a regular weekly report of Parliamentary debates which affect the engineering industry and profession, based on* Parliamentary Debates (Hansard) Official Reports.

THE BUDGET

When the two Houses of Parliament re-assembled on October 25, after an adjournment since July 28 for the summer recess, much of the immediate interest of industry and the general public centred on the presentation of the supplementary Budget in the House of Commons, which the country's existing monetary and economic situation has rendered necessary.

It was introduced on October 26 by the Chancellor of the Exchequer, Mr. R. A. Butler, with the House constituted, in accordance with practice, as a Committee of Ways and Means. Mr. Butler said that the fact that his speech would include budgetary measures might lead members to think that things were more difficult than they had imagined. Actually, there had been a distinct improvement during the past month: sterling had strengthened, the loss of reserves had been effectively halted and our current deficit in the European Payments Union had been greatly reduced.

Since the last Budget, over six months ago, rumours and speculation arose in July about the future parity of sterling and the margins within which it might move. This uncertainty was largely due to the discussions in Paris, in June, on subject of a European clearing system, and coincided with the emergence of a significant degree of internal inflation, due to wage claims, rising personal incomes, increased spending on both consumption and investment, and to industrial unrest.

The nation's difficulties, Mr. Butler said, were due to the growing pains of rapid changes and, in considering their cause and cure, we must reflect that we had not experienced the problems of a free economy for some 17 years, had taken on many overseas burdens and were sustaining a system of social services which was the envy of the world. Restraint was needed to enable us to combined internal expansion with external solvency and to ensure that the demands which resulted from full employment did not imperil our balance of payments.

So far this year, industrial production had run at between 5 and 6 per cent. above that of the corresponding period last year, but coal was a disquieting exception. The nation's exports, also, had improved. At the same time, the sum total of consumers' expenditure remained too high. The index of weekly wage rates rose by five points between December and March, when many large wage claims were settled, by another three points between March and June, and by a further point since. Reports by industrial companies in the first nine months of this year showed an increase in net dividends of 22 per cent. over the corresponding period of 1954.

In the field of fixed investments, the increase in the plans approved for new factory construction and the rising value of orders on hand for machine tools, pointed to a gathering momentum of demand, which, taken with an increase in industry's stocks and work in progress, and with the rise in incomes and consumption, was now overloading the economy.

WIELDING THE KNIFE

Action which the Government proposed to take to deal with the situation, Mr. Butler said, would include continuing to wield the knife in respect of Government expenditure, where the main possibilities of economy now lay in restraining the rate of development rather than in cutting back existing services.

At the Government's request, there would be economies by the nationalised industries. The gas industry would make do with older equipment, such as carbonisation plant, for a longer period and would be able to reduce expenditure this year by something approaching £3 million. The Central Electricity Authority had asked the area electricity boards for an all-round percentage cut in their expenditure in the current year, and even in the priority field of generation they had been able to postpone certain less vital projects while pressing on urgently with the nuclear-power programme.

The Chancellor said he had stated on July 26 that the coal mines must have their full investment requirements, but the National Coal Board were pursuing the possibility of saving, by deferring such projects as office buildings and brickworks, which did not affect output. The modernisation and re-equipment plan for British Railways was at an early stage of its development, but the British Transport Commission was well aware of the need for economy. Three major Government building projects would be halted.

Proposed changes in taxation to which the Chancellor referred included increases in telephone charges, purchase tax, and in the rate of tax on distributed profits, from 22½ per cent. to 27½ per cent.

Capital Spent on Technical Education

As was natural after a recess of nearly three months, a long and varied list of Questions awaited the attention of Ministers. In answer to one of them, Sir David Eccles, the Minister of Education, stated that between January, 1951, and May, 1955, work to the value of about £21½ million had been done on capital projects for technical and technological education.

Fishery Research Ship

Mr. James Stuart, the Secretary of State for Scotland, told members that the cost of the fishery-research ship Explorer was expected to be about £313,000 and that the vessel was likely to be ready for sea at the end of January next. She would be employed mainly in the nearer waters during her first year but would make occasional trips to the Faröes and more distant waters, and would be engaged on the collection of information about stocks of fish and sea conditions and in carrying out experiments with trawls and other gear.

Gas and Electricity Advertising

Mr. Geoffrey Lloyd, the Minister of Fuel and Power, said that, for the current financial year, the gas and electricity industries together were reducing their expenditure on advertising by nearly £500,000 and that this sum would be available for capital investment. He did not propose to regulate this advertising but would confer with the industries as occasion demanded.

Forth Crossing Projects

Forth-crossing projects were the subject of other questions. Mr. Stuart informed the House that the report of the panel of experts who were considering the respective merits of the bridge scheme and the tube scheme was being awaited. On the following day, Mr. John Boyd-Carpenter, Minister of Transport and Civil Aviation, stated that the panel was making good progress in assessing the comparative costs and might be able to submit a report dealing with this aspect in four or five months' time.

Report of Atomic Energy Conference

Sir Anthony Eden, the Prime Minister, said, in reply to questions, that the United Kingdom had made a notable contribution to the recent Geneva conference on the peaceful uses of atomic energy and to the exhibitions connected with it. He promised to look into the cost to members of reports of the conference, which were said to amount to £39, and that was a reduced amount.

Employment in Basic Industries

Mr. Harold Watkinson, Parliamentary Secretary to the Ministry of Labour and National Service, stated that, in the first eight months of 1955, the number of persons employed in the basic industries increased by 72,000, which, although largely a seasonal increase, was 17,000 more than in the corresponding months of 1954. There had been a decline by 6,000 in coal mining in the first nine months of this year.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

LONDON
"Electronics in Industry," by Dr. L. E. C. Hughes. South West London Branch. Guild House, 32 Worple-road, Wimbledon, S.W.18. Wed., Nov. 9, 8.15 p.m.
BIRMINGHAM
"Roller-Bearing Applications," by C. S. Clarke. Birmingham Branch. Birmingham Chamber of Commerce, 95 New-street, Birmingham. Wed., Nov. 9, 7.15 p.m.
BRISTOL
"Back-Pressure Steam Turbines," by D. N. de Mattos. Bristol and West of England Branch. Grand Hotel, Bristol. Fri., Nov. 11, 7.30 p.m.
SHEFFIELD
"Radio-Frequency Heating," by J. Pound. Sheffield Branch. Royal Victoria Station Hotel, Sheffield. Mon., Nov. 7, 7.30 p.m.
YORK
Discussion on "Electrical Equipment for Motor Vehicles." York Branch. The Shambles Café, York. Wed., Nov. 9, 7.15 p.m.

British Institution of Radio Engineers

GLASGOW
"Applications of Electronics to Marine Echo-Sounding," by F. Baillie. Scottish Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Thurs., Nov. 10, 7 p.m.
LIVERPOOL
"Dekatron Tube in a Digital Transmission System," by G. Shand. Merseyside Section. Liverpool Chamber of Commerce, 1 Old Hall-street, Liverpool, 3. Wed., Nov. 9, 7 p.m.
NEWCASTLE-UPON-TYNE
"Turret Tuners for Multi-Channel Television Reception," by R. Holland. North Eastern Section. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Wed., Nov. 9, 6 p.m.
WOLVERHAMPTON
"Closed-Circuit Industrial Television," by H. A. McGhee. West Midlands Section. Wolverhampton and Staffordshire Technical College, Wulfruna-street, Wolverhampton. Wed., Nov. 9, 7.15 p.m.

British Interplanetary Society

LONDON
"Space Travel and Future Research into the Structure of the Universe," by Dr. J. M. K. Kooy. Caxton Hall, Victoria-street, S.W.1. Sat., Nov. 12, 6 p.m.

British Welding Research Association

BIRMINGHAM
Various papers on welding and design techniques. College of Technology, Suffolk-street, Birmingham. Wed., Nov. 9, 9.30 a.m. and 2.30 p.m.; and Thurs., Nov. 10, 9.30 a.m. and 2.30 p.m.

Building Centre

LONDON
Films: "White Lead"; and "Magnet: A White-Lead Paint." Wed., Nov. 9, 12.45 p.m.

Chemical Engineering Group

LONDON
Technical Films. Geological Society, Burlington House, Piccadilly, W.1. Tues., Nov. 8, 5.30 p.m.

Chemical Society

BANGOR
"Experiences in an Industrial-Research Laboratory," by Dr. M. A. T. Rogers. North Wales Branch. Chemistry Department, University College of North Wales, Bangor. Thurs., Nov. 10, 5.45 p.m.
BRISTOL
"Problems Involved in Studying Fast Reactions," by Professor H. W. Melville. Bristol Branch. Chemistry Department, The University, Bristol. Thurs., Nov. 10, 5.15 p.m.
EDINBURGH
"Hydrogen-Transfer Reactions," by Professor E. A. Braude. Edinburgh Branch. North British Hotel, Edinburgh. Thurs., Nov. 10, 7.30 p.m.
LIVERPOOL
"The Chromatography of Gases and Vapours," by Dr. F. H. Pollard. Liverpool Branch. Chemistry Department, The University, Liverpool. Thurs., Nov. 10, 5 p.m.

Illuminating Engineering Society

LONDON
"Efficiency of Fluorescent Lamps," by F. Jackson, R. Molloy and K. Sott. Lighting Service Bureau, 2 Savoy-hill, W.C.2. Tues., Nov. 8, 6 p.m.
HULL
"Some Developments in Fluorescent Lighting," by H. H. Ballin. Leeds Centre. Offices of the Yorkshire Electricity Board, Ferensway, Hull. Mon., Nov. 7, 7 p.m.
NEWCASTLE-UPON-TYNE
"The Architect's Approach to Artificial Lighting Design," by G. Grenfell Baines. Newcastle Centre. Department of Electrical Engineering, King's College, Newcastle-upon-Tyne. Wed., Nov. 9, 6.15 p.m.

Incorporated Plant Engineers

BIRMINGHAM
"Wire Ropes," by N. B. Yates. Birmingham Branch. Imperial Hotel, Birmingham. Fri., Nov. 11, 7.30 p.m.
GLASGOW
"Modern Textile Drying Methods," by K. S. Laurie. Glasgow Branch. Scottish Building Centre, 425/427 Sauchiehall-street, Glasgow. Thurs., Nov. 10, 7 p.m.
LIVERPOOL
"Steam for Process," by L. G. Northcroft. Merseyside and North Wales Branch. Royal Institution, Colquitt-street, Liverpool. Thurs., Nov. 10, 7.15 p.m.
MANCHESTER
Film Evening. Manchester Branch. Engineers' Club, Albert-square, Manchester. Tues., Nov. 8, 7.15 p.m.
NEWCASTLE-UPON-TYNE
"Fuel Additives," by Commander E. G. Wood. North East Branch. Roadway House, Oxford-street, Newcastle-upon-Tyne. Thurs., Nov. 10, 7 p.m.
NOTTINGHAM
"Atomic Energy and the Future," by J. A. Dixon. East Midlands Branch. County Hotel, Theatre-square, Nottingham. Wed., Nov. 9, 7 p.m.

Institute of British Foundrymen

BRADFORD
"CO_2 Process," by A. Tipper. West Riding of Yorkshire Branch. Technical College, Bradford. Wed., Nov. 9, 7.30 p.m.
LINCOLN
"Core Blowing," by G. W. Fearfield. Lincolnshire Branch. Technical College, Lincoln. Thurs., Nov. 10, 7.15 p.m.
MANCHESTER
"The Manufacture of Marine Propellers, with Particular Reference to the Foundry," by J. M. Langham. Lancashire Branch. Midland Hotel, Manchester. Mon., Nov. 7, 7 p.m.
SHEFFIELD
"Relationship Between the Flowability of Moulding Sand and Casting-Surface Finish," by H. H. Fairfield and James McConachie. Sheffield Branch. College of Commerce and Technology, Pond-street, Sheffield, 1. Mon., Nov. 7, 7.15 p.m.

Institute of Fuel

LONDON
"Chimneys and the Dispersal of Smoke," by J. E. Hawkins and G. Nonhebel. Institution of Civil Engineers, Great George-street, S.W.1. Wed., Nov. 9, 5.30 p.m.
BIRMINGHAM
"Work Entailed in Creating Smokeless Zones," by Ronald Williams. Midland Section. Imperial Hotel, Temple-street, Birmingham. Wed., Nov. 9, 6 p.m.
EDINBURGH
Film Evening. Scottish Section. North British Hotel, Edinburgh. Thurs., Nov. 10, 7 p.m.

Institute of Metals

LONDON
"The Shape of Grains in Single-Phase and Two-Phase Alloys," by Professor Cyril S. Smith. Royal Institution, 21 Albemarle-street, W.1. Tues., Nov. 8, 8.30 p.m.

Institute of Petroleum

LONDON
"Preflame Reaction in a Diesel Engine," by Professor F. H. Garner, G. H. Grigg, Professor F. Morton and Dr. W. D. Reid. Wed., Nov. 9, 5.30 p.m.

Institute of Road Transport Engineers

BIRMINGHAM
"Indivisible Loads," by S. Bowskill. Midlands Centre. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham. Tues., Nov. 8, 7.30 p.m.
CARDIFF
"Tyres and Steering Geometry," by J. H. Hardman. South Wales Group. South Wales Institute of Engineers, Park-place, Cardiff. Fri., Nov. 11, 7 p.m.
EDINBURGH
"A Talk on Fibreglass for Road Transport," by C. M. Johnson. Scottish Centre. North British Hotel, Edinburgh. Mon., Nov. 7, 7.30 p.m.

Institute of Welding

LONDON
"Automatic Argon-Arc Welding of Low-Alloy Steels," by F. G. Wilkinson. North London Branch. Manson House, 26 Portland-place, W.1. Thurs., Nov. 10, 7.30 p.m.
"Reclamation of Plant and Machinery by Welding," by G. Gordon Musted. South London Branch. 2 Savoy-hill, W.C.2. Thurs., Nov. 10, 6.30 p.m.

Institution of Chemical Engineers

BIRMINGHAM
"The Handling of Alcohols and Other Solvents," by F. H. Walmsley. Midlands Branch. Birmingham and Midland Institute, Paradise-street, Birmingham. Wed., Nov. 9, 6.30 p.m.

Institution of Civil Engineers

LONDON
"The Development of Sewage Treatment in the City of Coventry," by Granville Berry and C. R. Deeley. Public Health Division. Tues., Nov. 8, 5.30 p.m.
HULL
"Technological Education," by Emlyn Jones, Dr. B. Pugh and A. Fisher. Yorkshire Association. Offices of the Yorkshire Electricity Board, Ferensway, Hull. Wed., Nov. 9, 6.15 p.m.

Institution of Electrical Engineers

LONDON
Discussion on "Lagrange's Principle as the Basis of a Unified Treatment of the Action of Electrical Indicating Instruments," opened by D. Rutenburg. Education Discussion Circle. Mon., Nov. 7, 6 p.m.
"A Transistor Digital Fast Multiplier with Magneto-Strictive Storage," by Dr. G. B. B. Chaplin, R. E. Hayes and A. R. Owens. Radio and Telecommunication Section. Wed., Nov. 9, 5.30 p.m.
"Germanium and Silicon Power Rectifiers," by T. H. Kinman and others. Thurs., Nov. 10, 5.30 p.m.
BIRMINGHAM
"Electrification of the Manchester-Sheffield-Wath Lines, Eastern and London Midland Regions, British Railways," by J. A. Broughall and K. J. Cook. South Midland Centre. James Watt Memorial Institute, Great Charles-street, Birmingham. Mon., Nov. 7, 6 p.m.
DERBY
"Electrification of the Manchester-Sheffield-Wath Lines," by J. A. Broughall and K. J. Cook. East Midland Centre. Offices of the East Midlands Electricity Board, Derby. Tues., Nov. 8, 6.30 p.m.
LIVERPOOL
"The Standardisation of Retail Electricity Tariffs," by A. O. Johnson and N. F. Marsh. Mersey and North Wales Centre. Royal Institution, Colquitt-street, Liverpool. Mon., Nov. 7, 6.30 p.m.

Institution of Engineering Designers

ROCHESTER
"Design and Application of Vee-Belt Drives," by J. Mitchell. Bull Hotel, Rochester. Tues., Nov. 8, 7 p.m.

Institution of Engineering Inspection

LONDON
"Quality Control During High-Speed Diesel-Engine Manufacture," by G. Bird. Royal Society of Arts, John Adam-street, W.C.2. Wed., Nov. 9, 6.45 p.m.

Institution of Engineers and Shipbuilders in Scotland

ABERDEEN
"Fatigue Research at the Mechanical Engineering Research Laboratory," by C. E. Phillips. Robert Gordon's Technical College, Aberdeen. Fri., Nov. 11, 7.45 p.m.

Institution of Heating and Ventilating Engineers

LONDON
Various papers on "Corrosion," by D. G. Lewis, H. Campbell, P. Hamer and Dr. F. Wormwell. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Wed., Nov. 9, 5.30 p.m.

Institution of Mechanical Engineers

LONDON
"Disk Brakes," by F. G. Parnell and F. J. Bradbury. Tues., Nov. 8, 5.30 p.m.
Discussion on "Practice Arbitration." Industrial Administration and Engineering Production Group. Thurs., Nov. 10, 6.45 p.m.
"A Criticism of the Technical Education of Recently-Qualified Engineers," by P. P. Love. Education Group. Fri., Nov. 11, 5.30 p.m.
BRISTOL
"The Application of Atomic Energy to Power Production," by Dr. S. C. Curran. Western Branch. Royal Fort, Bristol. Fri., Nov. 11, 7 p.m.
LEEDS
"Failure of Diesel-Engine Pistons and Cylinder Covers," by Professor J. A. Pope. Yorkshire Branch. The University, Leeds. Thurs., Nov. 10, 6.30 p.m.

Institution of Production Engineers

DONCASTER
"Production Methods in the Motor Industry," by E. C. Bishop. Doncaster Section. Danum Hotel, Doncaster. Tues., Nov. 8, 7 p.m.
LEICESTER
"Engineering Metrology," by J. R. Adams. Leicester Section. Bell Hotel, Leicester. Thurs., Nov. 10, 7 p.m.
NOTTINGHAM
"Relationship of Production Control to Costing," by H. P. Court. Nottingham Section. Mechanics' Institute, Burton-street, Nottingham. Wed., Nov. 9, 7 p.m.
PRESTON
"Modern Finishing Processes," by K. W. Abineri. Preston Section. Victoria and Station Hotel, Church-street, Preston. Wed., Nov. 9, 7.15 p.m.

Institution of Structural Engineers

COLWYN BAY
"Recent Trends in the Design of Industrial Buildings," by A. V. Hooker. Wales and Monmouthshire Branch. County Buildings, Colwyn Bay. Sat., Nov. 12, 6 p.m.

Junior Institution of Engineers

LONDON
"Nuclear-Research Installation at the Hammersmith Hospital," by F. A. Smith. Fri., Nov. 11, 7 p.m.

Newcomen Society

LONDON
"The Pre-Natal History of the Steamboat," by H. Philip Spratt. Annual General Meeting. Science Museum, South Kensington, S.W.7. Wed., Nov. 9, 5.30 p.m.

North East Coast Institution of Engineers and Shipbuilders

NEWCASTLE-UPON-TYNE
"The Optimum Diameter of Marine Propellers: A New Design Approach," by Professor L. C. Burrill. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Fri., Nov. 11, 6.15 p.m.

Royal Institution

LONDON
"Automatic Control and Production," by R. H. Macmillan. Tues., Nov. 8, 6 p.m.
"Large-Scale Weather Processes," by Dr. R. C. Sutcliffe. Thurs.. Nov. 10, 6 p.m,

Society of Engineers

LONDON
"Investigation into the Design of the Superstructure of a Power Station," by C. W. E. Dudley. Geological Society, Burlington House, Piccadilly, W.1. Mon., Nov. 7, 5.30 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
British Interplanetary Society, 12 Bessborough-gardens, London, S.W.1.
British Welding Research Association, 29 Park-crescent, London, W.1. (LANgham 7485.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Chemical Engineering Group, 56 Victoria-street, London, S.W.1. (VICtoria 6161.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester 3. (Blackfriars 6178.)
Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1. (LANgham 7124.)
Institute of Metals, 4 Grosvenor-gardens, London, S.W.1. (SLOane 6233.)
Institute of Petroleum, Manson House, 26 Portland-place, London, W.1. (LANgham 2250.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institute of Welding, 2 Buckingham Palace-gardens, London, S.W.1. (SLOane 9851.)
Institution of Chemical Engineers, 56 Victoria-street, London, S.W.1. (VICtoria 6161.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineering Designers, 38 Portland-place, London, W.1. (LANgham 8847.)
Institution of Engineering Inspection, 28 Victoria-street, London, S.W.1. (ABBey 3794.)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Newcomen Society, Science Museum, Exhibition-road, London, S.W.7. (Kensington 1793.)
North East Coast Institution of Engineers and Shipbuilders, Bolvec Hall Newcastle-upon-Tyne 1. (Newcastle 20289.)
Royal Institution, 21 Albemarle-street, London, W.1. (HYDe Park 0669.)
Society of Engineers, 17 Victoria-street, London, S.W.1. (ABBey 7244.)

THE HUMAN ELEMENT

Stock Exchange and trade union reaction to the Budget.—Amalgamation of unions brings new problems—Competition for workers.—What happens to graduates when they leave the universities.—And to national service men when they leave the Forces.—Sir Walter Monckton's wisdom.

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Wage Negotiations and the Budget

Not often does it happen that the Stock Exchange and the trade unions are in agreement on a particular aspect of the effect of a Budget on economic affairs. Last week, however, Mr. Butler achieved the embarrassing distinction of producing a set of proposals which both institutions decided would raise the cost of living. The Stock Exchange marked up prices; the unions marked up their wage claims.

Swift and hostile comment came from the National Union of Mineworkers, the National Union of Railwaymen, the Tobacco Workers Union and the National Union of Tailors and Garment Workers. They all condemned the proposals and let it be known that they would put in demands for higher wages or raise the bid at negotiations already in train. For unions like the miners and the railway men the Budget comes at a tactically good moment for it enables them to show their members that they are alive to their interests, it gives more workers a greater incentive to support wage demands (this is not a popular Budget with workers' wives, or anyone else's) and gives the union representatives one more argument for the employers to cope with round the table. Cromwell's cry of joy when the Scots gave him his "crowning mercy" by surrendering the tactical advantage at the battle of Dunbar must have been re-echoed by many a union negotiator when he heard of the Stock Exchange reaction to the Budget last week. No official comment has come as yet from the engineering unions, but their views at the forthcoming negotiations are also likely to be affected by the events of last week.

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Fewer Unions

These are the days of bigness. Although Britain is still predominantly a place of small companies there is a trend towards the concentration of industry in large concerns. The same development is to be seen in trade unionism. According to figures published by the Ministry of Labour Gazette recently, trade union membership last year was 9,495,000, which was 36,000 more than in 1953, but 31,000 fewer than in 1952. The fall in the number of trade unions continued over the year from 689 to 674, and for the years to come it is this second fact which is probably the more significant of the two. The process of amalgamation of unions continues steadily. In the last 15 years, the number of unions has dropped from over 1,000, that is by about 33 per cent. There are still 309 unions with a membership of less than 500 but there is a definite trend towards the concentration of trade union power in the 17 big unions.

This is probably inevitable, but it will be watched by thoughtful trade unionists, as well as the rest of the community, with mixed feelings. It means the end, in many industries, of the local union run by working men. It is the counterpart of the demise of the craftsman. It brings in big administrative machines, remote control of union policy and the growth of a professional trade union class. To-day, there is less and less of the master bargaining with the man; professional manager meets professional union representative. The rules of the game are more clearly defined and on the whole adhered to. There is less passion and more negotiation. In this world the big ships manoeuvre and show their armaments but rarely fight. Some of the irresponsibilities are taken out of management-labour relations at the local level but it has yet to be shown that other irresponsibilities do not emerge at a "higher" level.

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Poaching Workers

An interesting case of how Budget strategy might work was seen last week in the course of a two-day private session of the British Employers' Confederation on "The Future of Industrial Relations." The increasing signs that some employers are prepared to "poach" workers were criticised on the grounds that bidding of this kind tends to accelerate the upward movement of wages beyond the rate which conditions justify, and that these increases are reflected in costs and hence in prices which stimulate further wage demands and lower competitive power in export markets. "Poaching" on a significant scale is a sure sign that demand for goods is getting beyond the ability of industry, in the short run, to supply them—which is the problem which the Chancellor of the Exchequer has tried to solve with his autumn Budget.

Chapter and verse were provided for these generalisations at Birmingham towards the end of last week when the president of the National Federation of Building Trades Employers drew attention to the poaching problem in the building industry, where a certain amount of it has become evident. If the Chancellor's cuts in the housing subsidies reduced the rate at which local authorities build dwellings the tension in the labour market will be reduced. Such is the theory. It will not be until next spring (when the winter lull in building comes to an end) that the theory can be tested adequately in practice. If the theory is to be right, labour not required for building should be quickly absorbed elsewhere.

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Graduates' Jobs

Manufacturing industry tied with teaching in the recruitment of university graduates who finished their studies in 1950, each taking 23·4 per cent. of the total. Next came the civil service with 8·6 per cent., followed by commerce with 7·5 per cent., the universities themselves (4·2) and local government (3·6). These figures were obtained by Political and Economic Planning (P.E.P.) in a survey of the types of employment taken up by university graduates, and are based on nearly 4,000 replies to some 7,000 questionnaires sent out. The survey is part of a major inquiry into the employment of graduates in industry, which P.E.P. are undertaking on behalf of the Department of Scientific and Industrial Research.

As no comparable figures are quoted for pre-war years it is impossible to say whether or not manufacturing industry is increasing its share of available talent; one suspects that it is. Its share of the graduates who had achieved first-class honours—23·7 per cent. of the 493 in the sample—was the highest and compared with 17·8 per cent. who took up university posts and 9·3 per cent. who became school teachers.

The survey revealed that graduates tend to stay in their first job: two-thirds were still in it last autumn, after four years. A warning to companies who recruit graduates and treat them like school-leavers: manufacturing industry had lost 17 per cent. and commerce 25 per cent. of their recruits. Some of these may have been misfits, but the proportion is too high for comfort or complacency.

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The Call-Up and Careers

"The effect of the present two-year break in young men's careers is a subject which has aroused wide public interest and concern." This is taken from a report on an inquiry by the Ministry of Labour and National Service, published last week as a White Paper. Over 90 per cent. of the 13,436 national service men discharged in September, 1953, who voluntarily answered questions were satisfactorily settled, 80·3 per cent. in employment and 10·3 per cent. in further education.

The main conclusion of the inquiry is that "although national service must inevitably cause some disturbance in civilian careers, it does not create any major problems of employment or resettlement." Another conclusion is that the number of young men who return to their pre-service employment is higher where employers keep in touch with them during their time in the forces. Most of the misfits, who may at first sight appear to have been unsettled by national service, had poor employment records before they were called up. Those who had been apprentices or who had had jobs before they were called up had the least difficulty in settling down: the report infers from this that "vocational guidance is most effective when given some time before a boy is called up."

It is a pity that the inquiry was limited to the narrow field of resettlement after national service; the opportunity was there to find out how in fact young men evolve during those two years, what they learn, how they are trained and for what. Some of the public concern relates to the length of the service and to the way it is being used. The Advisory Council on the Relationship between Employment in the Services and Civilian Life, who requested this survey, have more on their plate.

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Sir Walter the Torch-Bearer

"I want to say something on this question of human relations in industry. I seldom miss the chance. It is quite fundamental." These words were spoken by Sir Walter Monckton to the British Employers' Confederation when he opened their conference on "The Future of Industrial Relations" last week. Two days earlier, in an address to the Guild of Cordwainers, human relations in industry was again his theme, as it has been on countless other occasions since he became Minister of Labour and National Service. Sir Walter preaches that understanding—mutual understanding of each other's points of view, problems and even prejudices and the effective communications which make this possible—are the keys to industrial peace and higher productivity.

Before the war he would have been sneered at from all sides; to-day, all listen and make good resolutions. He has friends throughout industry and many more who admire and respect him. Already he has helped to remove some of the ignorance and misconceptions which are commonplace and to foster the attitude of mind on which depends "the right handling of all problems of industrial relations and productivity." The following extracts from his speech should be read and re-read by trade union leaders as much as by employers:

". . . The old disciplines of fear and want have gone; the employer to-day depends on, and must thrive to foster, the willing co-operation of understanding of his men."

"By no means all strikes (indeed, in numbers if not in men involved, only a minority) are due to wage issues. Moreover, I think it is true to say that the apparent cause of a strike is very often not its real cause. Where there is something wrong in a firm and where there is no channel through which the views of the workpeople can be freely and quickly made known, a pressure of discontent will be built up which may result in a strike over an apparently quite trivial issue."

"It is most important that your workpeople should know the facts about your own industry and about your particular firm. There are very many problems in which a joint consideration of the situation based on a wide knowledge of the facts can be of immense value."